NEW ENVIRONMENTAL POLICY AND REALISATION OF KYOTO PROTOCOL IN RUSSIA

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This paper deals with the macroeconomic policy and its links with the new concept of the environment protection during the period of economic growth. It also deals with the domestic environment protection policy and solution of the global econogical problems. Analysis of the Kyoto Protocol is given together with the economic consequnces of its coming into force for Russia.

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Section 1. Macroeconomic policy and new environmental policy concept for the period of economic growth[1]

Russia's economic growth unfolding over the last five years so far has not led to a corresponding environmental burden growth. However, the extent of environmental reserves accumulated over the economic slump period can be exhausted if the economic growth is not accompanied with the application of new environmental technologies (see *Dudek et al 2002*). In these circumstances the magnitude of an active environmental protection policy increases.

Taking into consideration scantiness of resources that society can assign to the solution of environmental issues, the priority of environment protection measures becomes very important. On the one hand, issues that produce most negative effect on the environment and humans should be selected. On the other hand, a strategic decision related to which issues of environmental regulation should remain in the sphere of competence of the state and which issues should be transferred to entrepreneurs and the population at large.

Peculiarity of the Russian economy is such that a rational environmental policy most likely will not tell on the economic growth if such a growth is accompanied with the development of new technologies. For that purpose clear priority activities are required that are aimed at the limited number of environmental targets as well as an efficient mechanism for their realization that does not burden the economy as a whole and separate economic agents with unjustified costs and that permits to attain environmental goals with minimal costs.

1.1. Identification of the most important environmental issues for the next decade and evaluation of ecological and socio-economic consequences of environmental pollution

The state of environment and the growth of well-being of the population

The state of environment is in itself a public good. Its improvement or at least not worsening creates like investments in the human capital, science and education positive externalities. Together with the growth of common wealth when the growth level (usually per capita GDP) reaches a certain level the demand on the quality of environment starts growing. It grows faster than the demand on goods and services on average. In case when income growth of the

[1]This paper uses material provided by a NGO "Protection of Nature".

population is accompanied with a reduction in income differentiation then mentioned externalities become global and the income growth automatically leads to environmental improvement. In literature this phenomenon is called Kuznets ecological curve (See Golub et al 2003).

Russian economic growth leads to income differentiation growth. That is why we assume that Kuznets ecological curve phenomenon will not be observed. In Russia, most likely, discrepancy between the aggregate demand on environmental quality and its real quality will be growing. Most acutely this issue is related to the free air. The population is taking individual precautions with respect to portable water. Income growth increases demand on water filters and bottled water. Atmosphere protection from pollution requires coordinated measures. Active state regulation is required up to that moment when income differentiation growth is replaced with income differentiation decline.

Below we site some loss evaluation from a negative influence on people's health.

Epidemiological estimates

Epidemiologists *Revich and Bykov 1998* conducted evaluation of mortality rate that was caused by free air pollution for the Russia on the whole (see *Revich and Bykov 1998*). According to their analysis, on average in Russia about 7 percent of deaths among urban population living in the most polluted areas (10 percent of the whole population) can be explained by polluted free air. For less polluted areas where about 40 percent of the population resides, this share comes to 0.04 percent. Cumulative amount of carcinogenic substances leading to the mentioned mortality rate does not exceed 10 percent and comes to about 0.5 percent of mortality rate linked with all neoplasms.

Estimates of morbidity rate caused from pollution-type externality was based on findings collected from several pilot regions[2] (*Onishenko 2002*) that demonstrated that the share of this morbidity rate amounts to 7–10 percent of the overall morbidity rate (3–15 percent asthma)[3] out of which 67 percent of morbidity is caused by free air pollution.[4] Meanwhile, the share of corresponding carcinogenic morbidity is evaluated at 0.1 percent.

Evaluation of morbidity and mortality rate caused by portable water pollution was not conducted for Russia as a whole and for foreign countries due to lack of epidemiological data. That is why evaluation of mortality rate caused by portable water pollution is difficult. It is only known that in Russia is insignificant. Mor-

[2] Novgorod, Samara, Rostov-on-Don, etc.

[3] National Action Plan on Environment Protection. Ministry of Health Care. Ministry of Natural Resources. 2000.

[4] Yu.P. Lisitsyn. Social Hygiene and Health Care organization. Moscow, 1992.

bidity share linked with organs of digestion caused by water pollution comes to 3–5 percent from all morbidity rate linked with organs of digestion and 20 percent of all infectious and parasitic sicknesses[5] and 0.1–0.15 percent of all oncological sicknesses.

Experts formulated the following assumptions regarding aggregate estimates of mortality and morbidity rates caused by environmental degradation in Russia.

1) **minimal estimate** (percent of a corresponding overall frequency rate)

caused by water pollution:

morbidity organs of digestion		3–5 percent
infectious and parasitic diseases		20 percent
neoplasms		0.05 percent
mortality rate	organs of digestion	N/A
neoplasms		N/A

caused by the air pollution:

morbidity organs of respiration		7 percent
neoplasms		0.1 percent
mortality rate	organs of respiration	2 percent of overall
neoplasms		mortality rate

2) **maximum estimate**

caused by water pollution:

morbidity organs of digestion		20 percent
infectious and parasitic disease		20 percent
neoplasms		0.2 percent

caused by the air pollution:

morbidity organs of respiration		10 percent
neoplasms		1 percent
mortality rate	organs of respiration	3 percent of overall
neoplasms		

On the whole, evaluation of the mentioned parts of corresponding morbidity levels and mortality rate represents predominantly estimates made by groups of experts from CPRP.

Instruments applied for risks evaluation so far does not permit to estimate these parts precisely. In future these estimates can be adjusted on the bases of new statistical data on special epidemiological research with application of risk evaluation methodology.

The *Table 1.1.* provides data on morbidity caused by the air and water pollution that were obtained on the basis of the above-mentioned coefficients.

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[5] According to data provided by the Center for Ecological Epidemiology, 2000.

Table 1.1

Estimates of morbidity and mortality rates caused by the air pollution and water pollution (minimal scenario)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Free air pollution	Morbidity per 1,000 persons	23,5	24,6	20,3	21,6	19,8	20,7	18,6	20,9	19,7	21,3	22,5
	Mortality rate per 100,000 persons	22,3	22,8	24,3	28,9	31,3	29,9	28,4	27,5	27,2	29,4	30,7
Water pollution	Morbidity per 1,000 persons	8,3	8,1	8,5	9,3	10,5	11,3	10,5	10,0	10,4	10,7	10,5
	Mortality rate per 100,000 persons	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na
Overall	Morbidity per 1,000 persons	31,9	32,7	28,8	31,0	30,3	32,0	29,1	30,8	30,2	31,9	33,0
	Mortality rate per 100,000 persons	22,3	22,8	24,3	28,9	31,3	29,9	28,4	27,5	27,2	29,4	30,7

Source: Authors estimates.

Table 1.2

Estimates of morbidity and mortality rates caused by the free air pollution and the water pollution (maximum scenario)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Free air pollution	Morbidity per 1,000 persons	33,7	35,2	29,0	31,0	28,4	29,6	26,7	29,9	28,3	30,4	32,0
	Mortality rate per 100,000 persons	33,5	34,1	36,5	43,4	47,0	44,9	42,5	41,3	40,8	44,2	46,1
Water pollution	Morbidity per 1,000 persons	12,5	12,4	13,2	14,2	15,5	16,7	15,6	14,7	15,3	15,8	15,4
	Mortality rate per 100,000 persons	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a	N/a
Overall	Morbidity per 1,000 persons	46,2	47,6	42,2	45,2	43,9	46,3	42,3	44,5	43,6	46,2	47,5
	Mortality rate per 100,000 persons	33,5	34,1	36,5	43,4	47,0	44,9	42,5	41,3	40,8	44,2	46,1

Source: Authors estimates.

Thus, the number of morbidity cases caused by the air pollution considerably surpasses the number of morbidity cases caused by the water pollution. In selecting priorities for the environmental policy special attention should be paid to the air pollution.

Pecuniary estimate of damage caused by pollution-type externality

Pecuniary estimate of damage linked with pollution-type externality was conducted by using methodology of "sickness cost" (for morbidity) and "benefits transfer" (for mortality rate) (*Dixon et al 2000*). All estimates were done in US dollars for the year 1990 along with purchasing power parity (PPP) for corresponding year using the Goskomstat data. Main assumptions for pecuniary estimate consisted in the following:

1. *Cost of sickness included:*

- **GDP loss per sickness.** It was evaluated as GDP per capita per day multiplied by 16 days (evaluation for an average sickness period in Russia).[6] At the same time GDP losses linked with oncological diseases were ignored. It was due to the fact that the share of oncological morbidity in the overall morbidity rate caused by environment pollution is insignificant and a human being can work for a certain period of time even with that disease.
- **Cost of insurance *(COI)*,** includes:
  a) **Expenses on public health care** (wages of medical staff, hospitals maintenance, etc.) was estimated as an annual public expenditure and public extrabudgetary funds compulsory health care insurance *(GNE)* divided by overall number of registered cases of sickness *(N1)* per year;
  b) **Household expenses on medicine and hospitalization** *(EHM)* (expenses on purchase of drugs, unaccounted expenses on medical assistance, expenses on hospitalization in public, ministerial and private hospitals, cost of services in out-patient facilities, cost of dentist assistance, cost of private doctors). According to evaluations done by the Information and social center in 1998 this kind of expenditures amounted to about 182.16 billion rubles (in formal and informal sectors) or about USD 43 billion purchasing power parity (PPP). Out of that amount 60.8 percent constituted expenses on drugs and medicines.[7] According to other sources, estimate of the aggregate expenditure of the population on medicine and hospitalization constitute about 60 billion

[6] Population of Russia in 1999. Moscow, 2000.
[7] V.E. Boikov. Expenses of Russia's population on medical services and drugs: findings of sociological monitoring/Sociology of power. Information and analytical bulletin. Moscow, 1999, No. 1, pp. 5-59.

US dollars in PPP[8] At the same time, capital assets value in the sphere of health care is not accounted.

Thus, the cost of a sickness is estimated by applying the following formula:

$$COI = \frac{GDP}{POP}\frac{16}{365} + \frac{GHE}{N_I} + EHM \ ,$$

where *POP* represents a number of population.

At the same time, estimates of costs linked with sickness suffering, readiness of the population to pay for risk aversion, cost of health care insurance were not done. That is why, our evaluations of sickness cost can be viewed as a low bound of mentioned estimation.

2. *"Estimation of an average life span".*

Methodology of "estimation of an average life span" has a purely statistical aspect and is linked with a risk concept. This methodology is not designed to estimate a specific life. In the circumstances when required Russian research is lacking estimation of an average life span was calculated on the basis of an index obtained for the USA (about 3,1 million dollars for the year 1990),[9] which corresponds to the estimates of a discounted income (according to rate of 3–4%) for the whole capable for work period. For Russia average life span index was calculated according to a method of benefits transfer (through the ratio of GDP per capita in Russia and USA on the basis of PPP) taking into consideration reduction of able-bodied period due to a reduction in the life span. Authors understand that this approach is rather relative and it can be analyzed only as an attempt in economic estimation damage for people's health loss caused by the pollution-type externality. Nevertheless, the risk-based approach remains the most widespread and acknowledged in the world. It was applied for calculating people's health loss in many European countries, USA and Canada. Executive and legislative branches of power took into account obtained results in their decision taking.

Analysis of morbidity cost demonstrated that by the end of the 1990s, the share of personal expenses in the overall expenditure on health care constituted about two thirds of the overall expenditure including public ones (See *Boikov 1999*). At the same time, public health care expenditure was gradually diminishing. Overall morbidity cost in real terms was estimated at 630–1,161 US dollars per capita. Estimation of an average life span in Russia went down together with a reduction in the ratio between PPP in Russia and USA. It constituted about 800–1,600 US dollars.

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[8] Population of Russia in 1999. Moscow, 2000. P. 102.

[9] EPA, 1990, etc. http:/www.epa.gov. At present, these data varies for the USA between 2 and 5 million dollars.

Table 1.3

Sickness cost and average life span in Russia in 1990–2000 (according to PPP)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Cost of disease, bln dollars US per capita	Medical treatment cost	673*	604*	559*	477*	420*	391	392	457	383	327	344
	GDP losses	489	465	399	363	317	305	288	297	284	303	333
	Overall	1 161	1 069	958	841	737	696	681	754	666	630	677
GDP per capita, thousands US dollars per capita		11,15	10,6	9,1	8,3	7,2	6,9	6,6	6,8	6,5	6,9	7,6
Russian GDP per capita. GDP per capita in US in percent		53%	50%	41%	39%	33%	30%	28%	29%	26,2%	28%	31%
PPP, Rbl./US dollar		0,37	0,84	13,35	132,15	541,8	1497,0	2209,0	2528,0	2,8	4,7	6,6
Estimate of an average life span, US dollars per capita		1 655	1 546	1 267	1 209	1 025	921	871	888	811	880	957

Note: * Authors estimate after 1998 ruble denomination (divided on 1000).
Source: Goskomstat of Russia: GDP per capita, PPP; authors estimates: disease cost, Russia's and US GDP ratio, cost of an average life.

Table 1.3. illustrates estimates of ecological costs for people's health. It is worth noting, that according to our minimum and maximum scenario overall people's health damage as a result from pollution-type externality in separate years during the period from 1990 through 2000 was estimated between 3.6 and 7.1 percent of GDP (on average 4–6 percent of GDP) or correspondingly 57.4–76.2 billion US dollars. At the same time, free air pollution-type externality was about ten times higher than water pollution-type externality. Moreover, 95 percent of the cumulative damage caused by the mortality rate, resulted from a free air pollution. That is why, for example, when "cost estimate of an average life span" (for the USA) was taken at 2 million US dollars instead of 3.1 million dollars. In other words, when it was reduced by 35 percent obtained damage indices on average come down by 33 percent and constitute 2.7–4.1 percent of GDP.

Cumulative maximum people's health damage can constitute about 7 percent of GDP. Obtained loss estimates from pollution-type externality in Russia are comparable with the same estimates done for Western countries or even exceed them. For example, research conducted in the framework of European projects GARP and TEPI demonstrated that in case of the European countries, people's health damage from pollution-type externality on the macro level comes to 3–5 percent of GDP.

Table 1.4

Minimum and maximum cost estimates for the health of the population of Russia caused by free air and water pollution in the years 1990–2000 (according to PPP)

			1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Water pollution cost	Bln US dollars	MIN	1,4	1,3	1,2	1,2	1,1	1,2	1,1	1,1	1,0	1,0	1,0
		MAX	2,1	2,0	1,9	1,8	1,7	1,7	1,6	1,6	1,5	1,5	1,5
	% of GDP	MIN	0,09	0,08	0,09	0,09	0,11	0,11	0,11	0,11	0,11	0,10	0,09
		MAX	0,13	0,12	0,14	0,14	0,16	0,17	0,16	0,16	0,16	0,14	0,14
Free air pollution cost	Bln US dollars	MIN	58,8	56,1	48,7	54,7	49,8	43,0	38,4	38,4	34,4	40,0	45,0
		MAX	87,9	83,9	72,8	81,9	74,5	64,4	57,5	57,4	51,5	59,8	67,3
	% of GDP	MIN	3,6	3,6	3,6	4,4	4,6	4,2	4,0	3,8	3,6	3,9	4,1
		MAX	5,3	5,3	5,4	6,6	7,0	6,3	5,9	5,8	5,4	5,9	6,1
Pollution type externality total cost	Bln US dollars	MIN	60,2	57,4	49,9	55,9	50,9	44,2	39,5	39,5	35,5	41,0	46,0
		MAX	90,0	85,9	74,7	83,6	76,2	66,1	59,1	59,0	53,0	61,3	68,8
	% of GDP	MIN	3,6	3,6	3,7	4,5	4,8	4,3	4,1	4,0	3,7	4,0	4,2
		MAX	5,5	5,5	5,5	6,8	7,1	6,4	6,1	5,9	5,6	6,0	6,2

Source: Authors estimates.

Thus, damage from free air pollution ten times exceeds the damage caused by water pollution. That is why, immediate measures should be concentrated on regulation of emissions in the atmosphere. Moreover, research findings show that according to risk estimate for the health of the population main attention should be immediately concentrated only on three basic pollutants: dust, emissions of sulfur and nitric oxides. These pollutants constitute more than 90 percent of pollution. At the same time, as studies on risk management demonstrate (Onishenko et al, 2002) that Russia possesses a considerable potential low cost and recoupment of measures directed at reducing pollution volumes. The aim of the short-term policy (10 years) can become stabilization of the emission levels of the fixed one.

1.2. The link between ecological policy and exploitation of natural resources

The GDP fall between 1991–1998 became one of the reasons for a reduction in the environmental pollution. At the same time, emissions per unit of GDP considerably grew during the period between 1990–1995. This tendency continued right up to 1998–1999. However, then it turned to the contrary. At present CO_2 emissions, for example, are lower than they were in the year 1990 calculated per GDP unit. Such positive changes became possible thanks to a cardinal shifts in GDP structure in favor of services sector and other sectors of the economy that differ with considerably lower environmental burden. Price reform was also a positive factor. Ending of hidden energy subsidies influenced the economy on the whole. It undoubtedly stimulated their saving (*Gurvich et al 1997*). This fact resulted in the improvement of weighted indices.

Natural resources sector of the Russian economy is its major element. It secures inflows of differential rent payments to the Russian economy in the form of tax revenues and in the form of the mentioned hidden energy subsidies. However, its outstripping development can undermine the basis for economic growth. Increase in the volume of natural resources production requires each time higher cost due to a diminishing marginal investment return in the mining sector. Its growth acceleration can lead to the fact that all rent will be spent of investments. In that case Russian economy will loose a very important source of support for other sectors development including new industries where a growing return to scale is notable. It is rather understandable that a hyper growth of the mining sector will result in a fast worsening of environment. It will happen not only at mining sites but mainly at the sites of transformation and consumption of raw materials. For example, increase in consumption of low quality coal on the European part of Russia. That is why a reasonable curbing of the mining sector growth by way of withdrawal of unstable differentiated windfall revenues (creation of a stabilization fund) will contribute to a more rapid economic growth. At the same time, this fact will allow to turn that growth into a cleaner one from ecological point of view.

At present there is a need in developing of sustainability indicators and methods of their empirical evaluation required for the development of an efficient long-term policy at the federal and regional levels. Here we propose to apply methodology for calculating indicators of stability for transitional Russian economy.

We base our research on the well-known publication of *Hartwick 1977*, *Dsgupta and Maler 1991*, and *Weitzman 1976*. These publications demonstrate that economic stability can be determined by estimating the influence of mining of minerals on the welfare of the country in the long run. Different concepts that can be used for this purpose are offered in literature. Depreciation of the natural capital in Russia can be evaluated on the basis of calculation of Hotelling rent. A well-known Hartwick rule confirms that mineral rent should be invested in other types of capital (in particular, human built capital) in order to that the consumption level (or utility) does not diminish with time. Thus, Hotelling rent can serve as an important indicator for a required investment in the economy.

According to a generalized stability criterion the consumption volume should not diminish with time. This requirement can be understood as a non-diminishing level of well-being that is represented by Haxian revenue and can also be approximated as a net product (NP). Another approach is based on the valuation of net investment (NI) as an potential index for regional economic development.

In 1980s a number of research projects on Hotelling rent were conducted in Russia (*Vavilov et al 1986; Vavilov, Volkonsky, Eskin 1988; Sakhovaler, Eskin 1983*). However, all of them analyzed command and administrative economy of the former USSR.

Transition to a market oriented economy in Russia started in 1992 with the implementation of the program of mass privatization, price liberalization and liberalization of external economic tires, considerable reduction in public expenditure, restructuring of public enterprises, etc. So big changes in the national economy were accompanied with large fluctuations of all macroeconomic indicators. That in its turn considerably influenced economic stability of mineral consumption in the country. That is why, in determining the time period of our analysis we took into account specific features of Russian economic development in transition period. We also paid special attention to the correct use of macroeconomic and other indices necessary in obtaining a true picture of economic development of Russia and its regions.

The issue for estimating the development stability and natural capital become exceptionally urgent for regions and countries that possess mineral resources. For that it is necessary to answer the following questions:

- What are the main components of the natural capital and what is its contribution to the welfare of a region and a country?
- What are the channels and efficiency of use of natural capital on the federal and regional levels including distribution of benefits and costs of mining?
- How to stimulate the sustainable development of a region from the point of view of changing capital flows and institutional structure in the use of mineral resources?

Calculation of sustainability indicator for a country rich in the natural resources should take into account their consumption. For this purpose we apply a concept of the economic rent that represents depreciation of the natural capital. Under the capital evaluation of the natural resources in this case the current cost of rent flow for the period of their consumption is understood.

Valuation of economic discount of the natural capital is a good indicator for calculating regional potential and obtaining useful information for decision making in the sphere of economic policy in relation to the use of mineral resources. Economic discount takes into account a shift in the capital value of mineral deposits and the rent of their consumption. Each region should have a clear vision of economic rent and economic discount of the available mineral deposits in order to evaluate the efficiency of their mining and the level of stability of economic development.

Specific features of Russian transition economy require a correct taking into account of changes in macroeconomic indices on the valuation of flows and deposits of natural capital in order to avoid domination of financial factors while calculating stability. Both sustainability indicators (net product and net investment) demonstrate instability of economic development during 1994–1998 (*Strurkova et al 2000*). However, forecast of future values showed a more acceptable results (*Strukova et al 2000*).

At the same time, an unclear system of ownership and inadequate price signals (undervalued domestic prices) create premises for the inefficient development of Russian enterprises. They have big possibilities for increasing consumption of mineral resources at the level that exceeds the sustainability level. Exporters remain in the most favorable position. It is due to the fact that mineral export secures the highest revenues from the use of natural capital.

It is worth noting that the existing system of taxation of mineral resources does not create enough incentives for reinvesting funds obtained from the use of natural capital. (*Strukova et al 2000*) That is why the most obvious way for stimulating sustainable development on the region is formation of a targeted fund, which accumulates proceeds from the mineral resources taxation.

Moreover, it is necessary to implement institutional reforms in order to secure more efficient management of mineral resources. These reforms will guarantee fare distribution of rent between the state and enterprise, regional and federal levels in order to satisfy consumption of the present and future generations. The first step can be creation of a stabilization fund, which will allow accumulating an unstable in time fraction of differentiated revenue. It is also expedient for decision making to start using indices of sustainable development calculated taking into account depreciation of the natural capital.

Section 2. Links between domestic environmental policy and solution of global ecological problems

As was said in the previous chapter the biggest damage from pollution-type externality is linked with emissions of small particles, sulfur and nitric oxides. Emissions of these pollutants result from combustion of fossil fuels and it means that there is a connection between emissions of these elements and emissions of CO_2 – the most important of greenhouse gasses which is regulated by the Kyoto Protocol of the UN Framework Convention on the Climate Change.

American NGO “Environmental Defense” together with the World Bank, Russian Academy of Sciences, Russian Ecological Center, administrations and research centers of a number of regions conducted a number of research projects that demonstrate this connection (*Danilov-Danilian 2003*).

Availability of this connection allows stating that the management of the most dangerous atmospheric pollutants leads to a reduction in greenhouse emissions or to the contrary management of the greenhouse gasses leads to a solution of urgent environmental problems in Russia. That is why mechanisms for the management of the local and global pollution should be connected. That represents the cheapest and efficient way of formation of a state ecological policy for the near ten years.

2.1. Review of research projects demonstrating connection between the management of global and local pollution

Research project initiated by an NGO “Environmental Defense” was directed at the analysis of ecological and economic benefits that can be obtained together with a reduction of greenhouse gasses (GHG) in the implementation of different strategies of energy sector at the macro and local level in Russia (*Danilov-Danilian 2003*). Key conclusions that were analyzed in the research were connected with a reduction of environment pollution on people’s health. First of all this reduction was linked with emissions of sulfur dioxide, particulate pollutants, nitric oxides, carbon oxide, benzapiren, vanadium oxide, heavy metals and other substances. This kind of reduction can be achieved by reducing emissions of greenhouse gasses (mainly carbonic aid gas – CO_2) in power engineering. Special attention in the research was paid to the policy and technologies designed to reduce emission of greenhouse gasses in production of electric power and heating including municipal systems of heat supply. We also analyzed benefits obtained from a wide use of bio-fuel for energy supply in pulp and paper industry.

First research on the macro level was completed in 2001 (*Dudek et al 2002*). Up bottom approach was applied that demonstrated a potential positive influence of an aggressive policy designed to reduce emissions of greenhouse gasses in the whole country. Because the type and the scale of additional benefits depend on what kind of policy and investment strategy is being implemented in the country, to a considerable extent benefits are connected with a certain measures directed at reducing emissions of CO_2 which are influenced by a whole number of macro-economic factors characteristic for transition processes in Russian economy. For the purpose of analysis of additional benefits obtained from reduction of emissions of CO_2 findings of the latest research dedicated to forecast of atmospheric pollution have been used. These findings are represented in publications by *Golub and Strukova "Russia at GHG Market" and by Dudek, Golub and Strukova "Trade in Emission Rights in the Countries with Transition Economies".* Two "extreme" scenarios were analyzed. They determine CO_2 emissions in Russia. The first scenario reflects a positive influence of market reforms and incentives that are created by trade in quotas on GHG emissions. That results in a considerable CO_2 emissions reduction. The second scenario describes development of Russian economy that is based on the use of outdated inefficient technologies, increase in export of energy resources, negative shifts in the energy balance. In particular, considerable substitution of natural gas with coal. This scenario demonstrates the highest growth in CO_2 emissions.

On the basis of the two scenarios described above potential CO_2 and other harmful pollutants emissions were evaluated. Among them were particulate pollutants and sulfur dioxide (SO_2) for the period between 2008–2012 (*Dudek et al 2002*). Particulate pollutants emissions were analyzed from the point of view of the influence of particles less than 10 micron in size (PM_{10}) and less than 2.5 micron in size ($PM_{2,5}$). These environment pollutants most significantly influence on people's health in Russia. In particular, they influence the mortality rate from cardiac and lung diseases and lung cancer. CO_2 emissions cause the symptoms of respiratory diseases, change in lung functions, growth of the mortality rate from respiratory diseases.

Application of a macroeconomic model permitted (*Dudek et al 2002*) to calculate PM_{10} and SO_2 emissions for the period till 2010 for two scenarios of CO_2 emissions. Analysis of these results demonstrated that economic development based on the outdated technologies (scenario 2) will lead to a sharp growth of free air pollution and caused by it growth in human mortality rate. The difference between a "dirty" and a "clean" scenarios according to this index constituted about 30 additional deaths per annum per 100 thousand of the population. That means that a side effect from an aggressive policy directed at reducing GHG emissions can result in a reduction of health risk of about 35,000 deaths per annum for the whole population of Russia. This constitutes 2 percent of the overall human mortality in the country till 2010. In case the "dirty" scenario is implemented that number of additional deaths can become Russia's pay for the strategy of economic development according to which GHG emissions will be growing by 600 million tons of CO_2 on average for the period between 2008 and 2012. In other words, our analysis demonstrated that a CO_2 emissions reduction by 3.5 thousand tons preserves one human life in Russia.

In subsequent research projects that were finished by 2002 (*Danilov-Danilian 2003*) we used a "bottom to top" approach for the analysis of technological possibilities in reducing GHG emissions in the energy sector of a number of Russian cities. Research was conducted in cities of central Russia (Moscow), north-west (Great Novgorod), north (Novodvinsk) and south (Voronezh). These cities considerably differ in the level of economic development and the number of population. However, they have a lot in common in performance of systems of electricity and heat production which is important for our analysis. We have paid special attention to possibilities for GHG emissions reduction due to coal and heating oil substitution with natural gas and also improvement in performance of municipal systems of heat supply and increase in energy efficiency. In the Arkhangelsk oblast we have also analyzed benefits for the people's health obtained from a transition to the burning of biomass (*Danilov-Danilian 2003*).

In each city we compared strategies directed at reducing GHG emissions with basic scenarios based on the current structure of energy use and the level of energy efficiency. CO_2 emission reduction in power engineering was conjugated with a reduction in the volume of traditional pollutants. Risk analysis methodology was applied for the evaluation of their influence on people's health. Risk analysis procedure consists of four main steps:

- Step 1. Identification of danger – in present research it includes evaluation of fuel consumption and as a result emissions of priority pollutants typical for Russia and having clear cut dependencies "dose-reaction" which are necessary for quantitative evaluation of influence on people's health.
- Step 2. Application of coefficients that reflect dependency "dose-reaction" for the evaluation of risk coming from an increase in concentration of harmful substances in air. Chronic influence of chemicals lead to an emergence of two types of dangerous effects: 1) carcinogenic and 2) non-carcinogenic.
- Step 3. Evaluation of exposition – evaluation of duration and frequency of pollution influence on humans and number of humans that remain under their effect. This step also envisages modeling of dispersing pollutants in the air in order to obtain concentration of these substances in selected urban regions.

- Step 4. Characteristics of risk – evaluation of people's health risk, which corresponds to an exposition in each, analyzed scenario and submitting information on results uncertainty (error).

We have conducted two research projects at the country level and six regional research projects in the cities of Moscow, Nizhniy Novgorod, Novgorod, Voronezh, Velsk and Novodvinsk (*Danilov-Danilian 2003*). All research projects of additional benefits have confirmed a strong link between GHG emission reduction and traditional pollutants emission reduction that are harmful for people's health. Both policy measures directed at reducing GHG emissions and targeted investment projects in this sphere lead to considerable additional benefits for people's health.

Macroeconomic research conducted by "Environment Defense" have demonstrated (*Golub, Dudek et al 2003*) that the fuel burning remains the main source not only of GHG emissions but of a free air pollution, on the whole. In this research we used "up-bottom" approach (*Golub, Dudek et al 2003*) and analyzed shifts in GDP structure and technological base as main factors influencing GHG emissions and other substances in the atmosphere. However, it did not take into account a full meaning of change in the structure of the fuel balance. Local research projects and bottom up approach allowed more precisely determine both dependence of mortality risk from an increase in pollutants emissions in atmosphere and calculate risks on the local level with the help of modeling of emissions dispersing. No less important was the fact that we have determined consequences proceeded from the implementation of different strategies of power engineering and projects designed to reduce GHG emissions from the point of view of influence of people's health.

For the purpose of estimating additional benefits we selected cities of European part of the country (*Golub, Dudek et al 2003*) because there is a rather high risk of change in the fuel balance in the pilot region. We have analyzed additional benefits from different points of view. This allowed us to develop methodology of risk analysis on the basis of a profound analysis of influence of the fuel burning on people's health.

In (*Golub, Dudek et al 2003*) it was demonstrated that there were no linear links between CO_2 emission reduction and risk to people's health. They depend on the following factors:

- Sources location;
- Places of residence and population density;
- Meteorological conditions;
- Other factors that determine the influence of local pollutants.

Nevertheless, there is a certain link between these two indices. Transition from coal consumption to natural gas consumption results in considerable climate benefits and reduces risk to people's health. Research findings obtained in Moscow, Voronezh, Veliky Novgorod, Velsk and Nizhniy Novgorod confirm this conclusion (*Danilov-Danilian 2003*). Transition to the consumption of alternative sources of energy (bio fuel) which we analyzed in Novodvinsk also brings positive results. However, these results are not so important due to a limitation of available possibilities in consumption of bio fuel.

Particulate pollutants less than 10 micron in size and sulfur dioxide represent the most harmful substances for the people's health. They increase the mortality risk by 5 percent (Voronezh example). Sulfur dioxide also considerably influences the morbidity rate, especially respiratory diseases and asthma. In spite of the fact that general number of cancer cases is estimated as rather small in comparison with the risk coming from other types of pollution, individual cancer risk is rather high reaching the level of 10^{-4}. Moreover, in future in case of fast growth of an average life span and well-being carcinogenic risk will be higher taking into consideration possible shifts in the fuel balance in favor of increasing coal and heating oil consumption.

In order to develop ecological priorities it is necessary to determine polluting substances of the first and second levels of importance. To the first refer traditional pollutants. Second include soot, heavy metals, carcinogenic heavy metals and a number of other substances. Ratification of the Kyoto Protocol and creation of a system that manages GHG emissions allow preventing emissions growth of traditional atmospheric pollutants. GHG emissions reduction will lead to obtaining long-term ecological benefits on the global scale. And as a result, emissions reduction of local pollutants will have an immediate positive effect on the people's health.

2.2. Fuel structure in power engineering, greenhouse gas emissions and influence on the environment

According to our estimates, the IET and the Ministry of Energy of Russia data during last three years there appeared a trend for increasing the share of coal in the fuel balance. This increase, in the first place, is connected with the fact that power-engineering specialists view coal as a more secure type of fuel. Gas as before is supplied on limits. Gazprom striving to increase export supplies is trying to reduce gas supply to Russian energy sector.

At present coal consumption by large power engineering comes to about 100 million tons of equivalent fuel. According to the estimates obtained as a result of a research project conducted by the Institute of Forecasting of RAS, the World

Bank, NGO Environmental Defense, Stuttgart and Moscow Universities (*Golub, Dudek et al 2003*), by the year 2010 this consumption can increase up to 150 million tons. *Table 2.1* contains data on consumption of primary energy resources in the year 2000 and two scenarios of forecast for the year 2010.

These calculations are based on a premise that in order to securing a necessary production of energy by the year 2010 aggregate potential of electric power stations should grow from 214 million kw in 2000 up to 224 kw in 2005 and up to 247 kw in 2010 (*Golub, Dudek et al 2003*).

Table 2.1

Versions of fuel supply to thermoelectric power stations in Russia in the year 2010, mln tons of equivalent fuel

	Coal	**Heating oil**	**Gas**	**Total**
2000	80,1	19,9	163,6	263,6
2010 *Preservation of existent energy balance structure*	103,8	25,5	201,1	330,4
2010 *Increase of coal share*	154,0	22,4	156,8	333,2

Source: Calculation by the Institute of Forecast RAS.

Evaluation of additional emissions into the atmosphere

Shifts in the structure of the fuel balance will lead to an increase in emergence of harmful substances as it is shown in *Table 2.2*.

Table 2.2

Additional emissions to atmosphere along social and economic regions resulting from a shift in the energy balance structure (1998–2010), thousand tons (minimal estimate)

	Particulate pollutant	**SO2**	**NOx**
Total	2282	1316	388

Source: Authors estimates (*Golub, Dudek et al 2003*).

Mentioned emissions increase will result in a sharp growth of morbidity and mortality as it is demonstrated in the *Table 2.3*.

Table 2.3

Calculation results of additional annual morbidity and mortality in the year 2010

	Child morbidity	**Grown up morbidity**	**Mortality**
Social and economic regions	**Cases of Chronic bronchitis/year**	**Cases of chronic bronchitis/ year**	**Lost years of life/ year**
Northern region	2967	128	1811
North-western region	7313	318	4515
Central region	85133	3697	52604
Central black earth region	9815	424	5998
Volga region	15880	683	9668
Volga-Viatka region	13155	891	8541
Ural region	22400	969	13727
North Caucasus region	16814	727	10301
North Siberian region	9601	415	5882
East Siberian region	7419	320	4565
Far East Siberian region	496	21	305
Kaliningrad region	84	4	51
Total	191078	8595	117968
Transborder pollution	23662	1014	9084

Source: Authors estimates (*Golub, Dudek, et al 2003*).

Section 3. Macroeconomic analysis of the Kyoto Protocol: economic consequences of its coming into force for Russia

3.1. The Kyoto emission budget

The Kyoto Protocol has set quantitative obligations on reducing GHG emissions (emission budgets) for industrially developed countries listed in the Annex I to the Protocol. National emission budgets are calculated by way of multiplying emissions of a “base year” (for majority of countries it is the year 1990 but for some countries with transition economy base year can be a different one) on “target coefficient” which shows obligations of a country on emissions reduction. This coefficient is expressed in percentage points of emissions of the base year and is fixed in Annex B to the Protocol. Then an obtained product is multiplied by five, i.e. by the number of years in the first budget period (2008–2012).

Emission budget = (emissions of base year) ×(target coefficient) ×5.

Being the country with a transition economy Russia according to Article 3.5 of the Protocol can choose as the base year 1990 or any other previous one. In 1990 GHG emissions were the highest in the history of the Soviet Union. That is why the choice of that year as the base one seems to us quite logical because in that case Russia will receive the highest available emission budget.

In the First National Communication under the UN FCCC (http://unfccc.int/resources/docs/natc/rusnce1.pdf), which was published in 1995 the following valuation of GHG emissions in Russia in 1990 was given: 3,039 million metric tons (MMT) of CO_2 equivalent. Main GHG was carbonic acid gas (CO_2). According to a given in the mentioned document valuation carbonic acid emissions in 1990 constituted 2,372 MMT which amounted to 78 percent of the overall GHG emission. Aggregated data of Russian inventory of emissions are given in *Table 3.1*.

While choosing the volume of quantitative obligations on GHG emission reduction, Russia took into account a possibility for an economic growth in the future after the country overcomes an economic crisis. During negotiations on the Kyoto Protocol the Russian delegation could not foresee exactly whether economic growth will be accompanied with a reduction in a weighted GHG emission per GDP unit or not. Consequently, it was unclear, whether the emissions growth will be exceeding GDP growth or it will be lagging behind. According to one of three officially approved scenarios included in the First National Communication GHG emissions in Russia were to reach the level of emissions of the base 1990-year in the near future. In light of these forecasts it was risky for the negotiators to adopt tougher obligations and they preferred to keep emissions in the first budget period at the level of 100 percent of 1990 emissions. Thus, Russian emission budget constituted 15,195 MMT of CO_2 equivalent.

Table 3.1

Aggregate data on GHG emissions and sewage in Russia for the years 1990 and 1994

	1990	**1994**	
	MMT CO_2 equivalent per year	**MMT CO_2 equivalent per year**	**% of emissions 1990**
CO_2	2372	1660	70
CH4	557	412	74
N2O	70	40	57
Hydrofluorinecarbons, perfluorinecarbons, SF6	40	40	100
Cumulative emissions	3039	2152	70

Source: First National Communication (http://unfccc.int/resources/docs/natc/rusnce1.pdf).

Besides, at the Seventh parties conference that took place in Morocco in 2001 rules for the realization of the Kyoto Protocol were coordinated. At that conference limits for accepting purifying capacity of woods were determined according to the Article 3.4. of the Protocol. For Russia the limit was set at the level of 33 million tons of carbonic acid equivalent per year. That evaluated in CO_2 equivalent constitutes 121 million tons and during five years – 605 million tons. As a result, cumulative Russian emission budget comes to 15,800 million tons of CO_2 equivalent. Implementation of projects on forest-plantations (Article 3.3) and realization of additional projects according to Article 3.4 can enlarge this budget. According to Bureau of economic analysis estimates by using this resource Russia can obtain half a billion tons of CO_2 equivalent.

There are no any limitations beyond the year 2012. Negotiations will start most likely in 2005. If we follow the logic of the Kyoto negotiation process, than Russia can take on itself realistic obligations that will allow increasing GDP, and at the same time remaining a seller on quotas market. For this Russia in coalition with Canada and the United States must put a question of full absorption of carbonic acid gas on the territory of each of the country. The Kyoto phase 2008–1012 is important for the development of methods discounting absorption mainly according to the Article 3.4 of the Protocol.

3.2. Forecasts of GHG emissions in Russia and requirement in the use of quota for proper needs

Forecast of GHG emissions is important for the solution of issues connected with realization of the Kyoto Protocol starting with an issue of its ratification and ending with an issue of using quotas for supporting Russian exporters. Emissions forecast was at the basis of the Russian negotiating position in Kyoto when the Russian managed to obtain a quota equal to 1990 emissions, meanwhile the majority of countries received a quota that was a few percentage points less (European Union, for example, got minus 8 percent). Emissions forecast for the period 2012–2022 will be of principle for the negotiations on the following budget period.

Emissions forecast and to be more precise analysis of scenarios for emissions dynamics for the period 2008–2012 is important in order to solve finally an issue of ratification of the Protocol and to solve an issue of how to use this quota. In this chapter we will analyze different forecasts of GHG emissions and will discuss conditions for realization of each of them. This will allow determining the size of a free quota and drafting recommendations for managing GHG emissions.

Review of forecasts

FORECASTS FOR NATIONAL COMMUNICATIONS

We should underline the fact that this forecast (http://unfccc.int/resources/docs/natc/rusnce1.pdf) was based on a rather simple consideration. GHG emission in the year *t* were calculated as a linear function of GDP:

$$g(t) = a(t) \times Y(t), \qquad (3.1)$$

Where $a(t)$ – GHG emissions per year *t*, $a(t)$ GHG emissions per GDP unit in a year (t); $Y(t)$ – GDP in a year (t). This coefficient considered both GHG emissions reduction per a unit of energy production and a reduction in energy use per GDP unit.

Such is the simplest "model" of exogenous technological process. Key element in expert valuations became an annual GHG emissions reduction per unit of GDP for the whole forecast period. This reduction is important to know in order to be able to calculate coefficient $a(t)$. It is obvious that such "model" can not be greatly changed. Nevertheless, we analyzed different scenarios that contained suppositions on the GDP growth rates, annual reduction in GDP power consumption and annual changes of CO_2 emissions per unit of energy production (see *Table 3.2*).

Table 3.2

Description of various scenarios (key exogenous parameters) which were used in the Second National Communication for official forecast of CO_2 emissions

	Basic scenario (SNC-B)	**Probable scenario (SNC-P)**	**Optimistic scenario (SNC-O)**
% GDP growth per annum	4	4.4	4.4
Annual reduction in GDP consumption (energy use/GDP), %	–0.5	–1.6	–2.0
Annual CO_2 emissions reduction per a unit of produced energy, %	Unchanged	–0.1	–0.1

Source: Second National Communication, 1999 (http://unfccc.int/resources/docs/natc/rusnce2.pdf).

Such simplified approach ignores a whole number of important factors which determine dynamics of GHG emissions. For example, influence of main macroeconomic tendencies (shifts in GDP structure and energy balance, investments in the new technologies, reaction of the economy on price signals, etc.)

Moreover, methodology that was used for compiling the forecast slightly exaggerates the GDP and coefficient $a(t)$. The year 1994 (t=0) was selected as the base year for the forecast and coefficient $a(t)$ was calculated according the following formula:

$$a(t) = a(0) \times (1-\alpha)^t$$

where α is the sum of an annual reduction in GDP power consumption and annual shifts in CO_2 emissions per unit of energy production divided by 100.

Annual GDP was calculated by using the same formula:

$$Y(t) = Y(0) \times (1+\beta)^t$$

Where β is an annual GDP growth rate divided by 100. Thus, instead of the formula (3.1) we arrive to the formula (3.2):

$$(t) = a(0) \times (1-\beta)^t \times Y(0) \times (1+\beta)^t \qquad (3.2)$$

According to the accepted methodology GDP growth started in the year 1995. In reality the Russian economy started growing only in 1999. Moreover, for the last ten years the highest GHG emissions per GDP unit (weighted emissions) were observed in 1994–1996. (*Golub et al. 1999*). Due to the fact that 1994 was selected as the base year and a simplified formula was applied (3.2), CO_2 emissions forecasts are doubtful and overestimated and the Russian emission budget turned out to be “inflated” (see above). However, a more precise and complicated analysis could not remove uncertainties in CO_2 emissions forecasts in Russia.

Moreover, with time it became clear that forecasts of the first and second national communications underestimated indices of structural shifts in the economy and the influence of market oriented reforms on the emissions dynamics. Real trajectory turned out to be lower than it was forecasted. A new forecast differed from the previous one with more precise evaluations of the potential for reducing emissions per a unit of product.

The Third National Communication was submitted to the secretariat of the Convention at the end of 2002 (http://unfccc.int/resources/docs/natc/rusnce3.pdf). A forecast provided in that document confirms that the Russian economy under no circumstances will not exceed emissions level of 1990 during the life of the Kyoto protocol.

Table 3.3

Forecast estimates of CO_2 emission (Emission indices, 1990 = 2370 MтCO₂/year = 100%),

Year	Scenario I	Scenario II	Scenario III
2000	69,2 %	69,2 %	69,2 %
2005	74, 6%	72,0 %	78,4 %
2008	78,0 %	73,8 %	84,5 %
2010	80,4 %	75,0 %	88,9 %
2012	82,8 %	76,2 %	93,4 %
2015	86,7 %	78,0 %	100,7 %
2020	93,4 %	81,2 %	114,1 %

Source: Third National Communication, p. 89. (http://unfccc.int/resources/ docs/natc/ rusnce3.pdf).

As can be seen from the *table 3.3.* under any scenario CO_2 emissions will not exceed the 1990 emission level. This refers both to the cumulative (for five years) and annual emissions. In Annex 2 a corresponding chapter of the Third National Communication is given.

FOREIGN PUBLICATIONS

There are not so many foreign publications dedicated to evaluation of expected GHG emissions in Russia. Usually Russia is included in such publications as a component of the whole region, oftener as part of the former USSR (see *Ellerman et al. 1998; Mckibbin et al. 1998; Victor et al. 1998*) or as part of the Central and Eastern Europe and the former USSR (see *Richels 1999*).

Most widespread methods applied for making forecasts are multi Sectional models of the general balance of world economy (*Mckibbin, et al. 1998; Ellerman et al. 1998*). In other publications a combination of various models were used. For example, in IIASA publication (*Victor D. et al. 1998*) two models were used: 11-regional version of the macroeconomic model “Global 2100” at the upper level and a linear model of energy system “Message-3” at the lower level. As another example can serve an emission forecast in Kazakhstan. It was submitted by Kazakh delegation at KOS-5. The model of interbranch balance was supplemented from the “bottom” with the model of power engineering development. Authors of all this works indicated that GHG emissions in the Russian Federation should be much lower than those that were mentioned at the negotiations on emission budget that took place in Kyoto.

However, results obtained from different forecast publications strongly differ. Depending on the suppositions about the combination of main macroeconomic parameters, estimates of the Russian cumulative emissions budget for the first budget period vacillated from the volume set by 2,300 MMT less that adopted obligations up to the amount slightly exceeding Russian obligations according to the Protocol.

For example, in the IIASA publication it is demonstrated that different suppositions about the economic growth and technological modernization lead to different forecasts of CO_2 emissions. Authors of this publication analyzed three groups of scenarios.

Fast GDP growth in combination with insignificant reduction of demand on mineral resources used as sources of power evaluated in GDP unit (scenario A2) leads to the least quota surplus. According to another IIASA scenario included in the publication the difference between the expected emissions in Russia during 2008–2012 and the Kyoto emissions budget can reach 3,200 MMT of CO_2 equivalent. This scenario presupposes a lower GDP growth rate (about 4,5 percent per annum) and fast demand reduction on mineral resources used as sources of power evaluated in GDP unit.

BEA FORECAST

This forecast (Golub et al, 1998) reflects more precisely processes that are taking place in transition economies. It is due to the fact that this forecast is based on a model specially designed to formalize transitional processes. That is why there is a possibility for a more exact reflection both structural shifts that take place in the economy on the whole and stimulating influence of the market oriented reforms.

Model description

Due to the fact that CO_2 emissions constitute about 90 percent of the cumulative GHG emissions we will analyze in more detail CO_2 emissions. We have used the model of economic growth in conditions of transition economy for developing different scenarios of CO_2 emissions (see *Golub et al. 1998*). Usually in such cases it is reasonably assumed that there is an increased openness of the economy as a result of market oriented reforms. That is why domestic prices and domestic structure of various products consumption gradually approaches to the world market standards. At the same time, market oriented reforms lead to the substitution of outdated technologies with modern ones which are characterized with a higher efficiency. The model analyses three major factors of the transition period:

- GDP growth
- Shifts in GDP structure during the transition period
- Shifts if technological base, transition to the new technologies.

Endogenous technological process is the most important element of our model. Precisely this distinguishes it from the other models described above. Dynamics and GDP structure are exogenous parameters of the model and the share of new technologies is an endogenous parameter. The production volume is determined with the help of the following equation:

$Y(t) = AX1(t) + BX2(t)$

Where $Y(t)$ is the final product in year t,

A is direct input matrix for the outdated technologies,

B is direct input matrix for the new technologies,

$X1(t)$ is product, produced in year t with old capital (i.e. using outdated technologies),

$X2(t)$ is product, produced in year t with new capital (i.e. using new technologies).

In the framework of given model the difference between modern and outdated technologies is expressed in the difference of coefficient matrix of direct input. Usually new technologies require fewer resources than the outdated ones. Coefficient matrix A are calculated on the basis of the data analyses of the performance of the Russian economy at the beginning of 1990s. Matrix B provides a prototype for the future Russian technological structure, which is typical of the western countries. For construction of matrix B we used the data on the US economy (see *Gurvich et al. 1997*).

Relative availability of the outdated and modern production capacities in each sector of the economy creates constraints to the production vector and determines a proportion between $X1$ and $X2$. For each sector i primary product $x1_i$ is calculated (produced using "outdated" technologies) that should be less or equal "outdated" production capacities in the given sector $k1_i$. At the beginning of the transition period at produce is produced using outdated capacities. However, with time these capacities completely or partially are replaced with the modern ones. Production capacities in a year t are equal capacities of the previous year t–1 minus depreciation plus investments.

$K1(t) = K1(t-1) - D1(t-1) + I1(t-1)$ and

$K2(t) = K2(t–1) – D2(t–1) + I2(t–1)$.

Where $D1(t)$ and $D2(t)$ is depreciation of the outdated and f and $I1(t)$ and $I2(t)$ are investment in outdated and new technologies.

There is one more set of exogenous parameters and namely prices on energy resources (natural gas, coal and heating oil) and payments for pollution. Prices on the energy resources and payments for pollution influence the speed of technological re-equipment. The speed of retirement of the outdated capital depends not only on the equipment age but on the energy prices and payment for pollution. Free parameters determine the speed of physical retirement of outdated productive capacities and their replacement with the modern ones. Outdated technologies consume more energy and produce pollution in higher volumes. That is why price increase on energy and payments for pollution increase $I2$ and $D1$.

Energy prices were calculated as the difference between world prices and transportation costs. However, the model allows conduct calculations at different assumptions on price dynamics. Energy prices were subsidized considerably in the former Soviet Union (see *Gurvich et al. 1997*). That is why fast transition to new prices was impossible. That is why we analyzed different ways for reforming the structure of energy prices.

Combination of different assumptions on GDP growth and price reform of the energy resources allowed us to analyze different scenarios of dynamics of CO_2 and ordinary pollutants emissions.

Demand on primary sources of energy is an endogenous parameter. For each step t we calculate consumption volume of fossil fuels which later multiply on emissions coefficient for calculating CO_2 emissions (speaking about emissions coefficients, see *Dudek 2002*). Thus CO_2 emission is a linear consumption function of primary sources of energy, which is determined by a proportion of the outdated and new technologies. Emissions of ordinary pollutants are calculated by using emission coefficients for each production. These coefficients are different for modern and outdated technologies. Cleaning level of the waste gases depends on the payment for pollution. These issues are analyzed in more detail in Golub and Gurvich, 1998.

Calibration of the model and scenarios

Calibration of the model was performed for the first time in 1995 when we analyzed the effect of ending of the subsidies. That research was done on OECD request. Findings were published in (*Gurvich et al. 1997*). Some additional changes were introduced into the model during the research project "Russian National Strategy of GHG Emission Reduction" that was financed by the World Bank (*Gurvich et al. 1997*). In publications (*Gurvich et al. 1997*) and (*Golub et al. 1998*) we analyzed different scenarios that were constructed from different combinations of exogenous parameters of the model with the aim to identify how these parameters (GDP, energy prices, payment rates on pollution) influence on the volume of environmental pollution. In this paper we will analyze a scenario of a regular development without technological changes ("business-as-usual") and two "extreme" scenarios that provide up and bottom limits of CO_2 emissions estimate.

For presenting the findings in comparable type, we did not change such basic macroeconomic parameters as the growth rate and the GDP structure as well as the structure of the primary energy sources balance. It was assumed that by the year 2010 the GDP will reach 112 percent of the 1990 level. Detailed description of other exogenous parameters is given in *Golub et al. 1999*.

Scenario 1

Market liberalization and the price growth on the primary energy resources can create additional incentives for speeding up the process of technological modernization. We assumed that the capital market is rather developed and enterprises can invest in the project with normal profit rate. At the model level it means that there is a gradual transition of an "outdated" direct input matrix (for simplicity called outdated technologies matrix) to a "modern" one. We also assumed that only market itself creates incentives for technological retooling of enterprises and the capital market of developed enough to ensure investments inflow to the industry. No additional incentives are envisaged. Payments for free air pollution remain at a very low level. Neither CO_2 tax nor other economic instruments are incorporated in the scenario. This scenario we called **"Transition to new technologies" (M-NT)"**.

CO_2 emissions grow but slower that the GDP. Average emission during 2008–2012 equals about 77 percent at 1999 level. That is why the difference between the Kyoto obligations and forecast emissions will come about to 2,690 MMT> It is worth noting, that here we presented only CO_2 emission other GHG included in the Kyoto Protocol were not taken into consideration.

Scenario 2

At the beginning we modeled the influence of different incentives directed to reduce CO_2 emissions which are developed by legislative measures and participation in the world trade of quotas. The model we used is rather a simple one. Due to this fact the possibility for modeling different variants of climate policy is rather limited. However, the model really permits us to evaluate the influence of such instruments as payments for pollution and CO_2 tax which is interpreted as the price on a single quota on the world market.

Payments for the free air pollution by the ordinary pollutants were introduced in Russia in 1991 by the law on protection of the free air (see *Golub and Strukova 1994*). However, payments rates at present are on a very low level.

We have analyzed various scenarios "to modernize" the payments systems starting with drastic increase of the payments rates. As the model demonstrates that in order to achieve any significant effect the payments rates should be increased at least in 30 times (see *Golub, Gurvich 1998*). Then we analyzed the influence of a hypothetical CO_2 tax. The tax rate in the model differed from 2 US dollars up to 25 US dollars per ton of CO_2 equivalent. Dynamics of CO_2 emissions turned out to be very sensitive both e CO_2 tax and to a drastic payments for NOx and SO_2. Theoretically any of these payments or their combination can be used for cutting CO_2 emissions and common polluting substances. However, in life during last ten years we observed only a reduction in the effective payments rate. It is unlikely that this tendency will be changed in the future.

At present the real incentives for the Russian entrepreneurs to reduce GHG emissions consist in fuel saving and potential profit from the sale the saved quotas on the global carbonic acid market. In this context we interpret the CO_2 tax as a single quota price on the world carbonic acid market. In the present work we presented a scenario with 25 US dollars tax per metric ton of CO_2. We call this scenario **"maximum effect – new technologies and additional state regulation (M – NTR)"**.

In comparison with the first scenario, which was discussed above one, can observe an additional emissions reduction down to 900 MMT of CO_2 equivalent. If we add to this other GHG the difference will become even more notable.

Scenario 3

In this scenario the influence of the market-oriented reforms on the behavior of the enterprises is not so significant and domestic prices on the energy resources are still lagging behind the world ones. Even under a formal ending of subsidies consumers do not pay a "full market price" due to a well-known problem on the non-payments. Actually, efficient energy prices remain much below the nominal ones. Low prices result in the fact that the transition period to the new technologies is slowed down. At the same time, demand on the energy resources grows up. Slowing down of the modernization process of the production is explained not only by low energy prices but also by a lack of free investment capital. For modeling such a situation we artificially "switched off" the new technologies matrix. In other words, we assumed that the outdated fixed capital retired from the depreciation is replaced with the same one that has similar emissions coefficient. This scenario is called **"slow market oriented reforms" (M – SMR)**. In this scenario we also model negative shifts that take place in the energy balance when the natural gas is partially replaced with coal.

Discussion of the forecast findings

Findings that resulted from modeling show that Russia has bright future for participating on the quota world market. However, certain conditions are required for this. The main one is the success of the market oriented reforms.

Our forecasts are based on the modeling results. Time iterations cover the period starting from 1990 through 2012. Usually during the process of the restructuring of the transition economy a production slump and emissions reduction are observed. The following economic growth will be accompanied with emissions increase. The question is how fast the emissions will grow in relation to the GDP. In scenarios M-NT and M-NTR we assumed that the private sector would be sensitive to the new market signals (ending of energy price subsidies, possibility to sell or preserve emissions quotas, participation in carbonic acid market). We also assumed that investors would invest in the projects with "normal" inter-company profit rate (10–15 percent). As a result, enterprises would be able to introduce energy saving technologies and positive shifts in the GDP structure, energy balance, etc. would take place.

In case above mentioned conditions are not fulfilled then economic development will follow the third scenario. The CO_2 emissions will grow considerably and Russia will be facing quota deficit (to 200 MMT of CO_2 equivalent) in the first budget period. There is no technological modernization due to unstable economic situation in the third scenario. Subsidies are preserved at the 1997 level. Payments for pollution fixed at the 1997 level remain the main economic instrument. It is obvious that this scenario does not envisage efficient state regulation of GHG emissions. Economic growth takes place on the basis of "outdated" technologies. Russia has no access to the international capital market and there is a shortage of domestic investment. In other words, a possibility of realization of such scenario diminishes as soon as any source of investment to the Russian economy appears. For example, profit obtained from the sale of quotas. In *Table 3.4* we present CO_2 emissions forecast obtained by us in the above-mentioned scenarios.

Table 3.4

CO_2 emissions in billion tons (only CO_2 emissions are presented)

Scenario	2005	2008	2010	2011	2012
M-SMR	1.59	1.82	2.01	2.38	2.64
M-NT	1.4	1.8	2.0	2.1	2.3
M-NTR*	1.3	1.6	1.8	1.9	2.1

* Single quota price equals $25 per ton of CO_2.

We should note that dynamics of GHG emissions in Russia contains great uncertainties. The difference between trajectories M-NTR and M-SMR reaches 750 MMT of CO_2 equivalent (in sum for five years) or about 30 percent if the Russian emissions. Such a considerable “corridor” in the forecast appears because of an uncertainty of major economic indicators that influence the economic development for a long run. This is rather an unfavorable conclusion in case when the main aim of the research consists in a precise calculation of emissions. However, in case our main aim is to determine motive forces that “make” enterprises reduce emissions to a minimal level then our conclusions are sufficiently convincing. A chance for realization of a pessimistic scenario M-SMR increases if market institutions are underdeveloped or are nonexistent and the capital flow is insufficient for a wide scale introduction of new technologies.

3.3. Comparative analysis of forecasts and modern tendencies in dynamics of GHG emissions

Above-mentioned forecasts were made at different times and had different premises on the economic growth rates and changes in its efficiency. That is why we bring these forecasts to a comparable type. Taking into account the fact when each of the forecasts was made and parting from presented in it GDP growth rate, it is easy to calculate what will be the GDP by the year 2010. *Table 3.6* presents corresponding information. Moreover, we compare these forecasts along indices of energy efficiency. A more precise comparison is impossible due to the fact that the majority of analyzes forests were made on the basis of a simplified methods.

Table 3.5

A comparison of different forecasts on dynamics of GHG emissions

Scenario	GDP in 2010 in % to 1990	Increase in energy efficiency	CO_2 emissions in 2010 in % to 1990
SNS-O	110	Reduction of GDP energy use by 2% a year	97
M-SMR	112	Low technical modernization rates	84
M-NTR	112	High rates of technical modernization	76
TNC1	109	Reduction of GDP energy use by 3.7% a year	80.4
TNC3	102	Reduction of GDP energy use by 2% a year	88.9
A3 (Victor)	104		89

As was mentioned above, GHG emissions dynamics during the period starting with 1998 turned out to be much lower than it was forecasted. In this connection, it seems necessary to conduct additional calculations and estimate possible dynamics of emissions for the period till the year 2012. For that purpose we will use a simplified model. That model uses an index of GHG growth in percentage points per one percent of GDP growth (elasticity of GHG emissions along GDP). On the basis of the analysis of GHG dynamics and GDP for the period from 1998 through 2002 elasticity coefficient was equal 0.42. In 2003 the amount of CO_2 emissions was estimated between 1,580 and 1,640 million tons of CO_2 or 67-69 percent of the 1990 level. For making a forecast of CO_2 emissions we took the Program drafted by the Ministry of economic development and trade "Main directions of the socio-economic development of Russia for a long-term perspective" (http://www.economy.gov.ru/merit/76). GDP growth rate is envisaged at the level of 6.1 percent. Emissions in the year 2010 will amount to 83.4 percent of the 1990 level. For sensitivity analysis to the input data we examined several variants of this forecast.

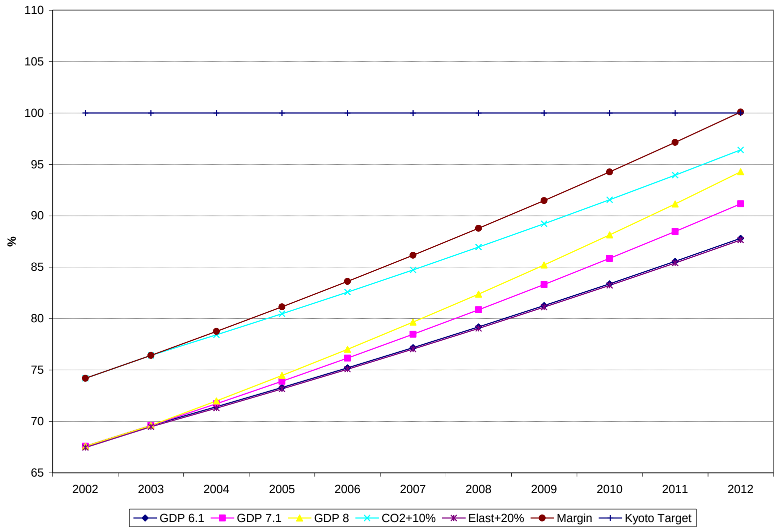
- In case of GDP growth at 7.1 percent a year CO_2 emissions in the year 2010 will amount 85.9 percent of the 1990 level. In case of GDP growth at 8 percent a year CO_2 emissions will grow up to 88.1 percent of the 1990 level. It is worth noting, that these figures can turn out to be somewhat overestimated due to the fact that elasticity of GHG along GDP is inversely proportionate to the GDP growth rates.
- Another variable whose influence we can check is the estimate of CO_2 emission in the year 2002. Research done by a non-governmental organization "Environment Defense" and dedicated to a precise inventory of the UES of Russia JSC (*Dudek et al. 2002*) showed that the error level did not exceed 4 percent. Taking into account the fact that in other sectors the level of precision can be lower we will analyze maximum error in 10 percent. In that case CO_2 emissions in the year 2010 will come to 91.6 percent of the 1990 level.
- If elasticity coefficient increases by 20 percent and will equal 0.5 then CO_2 emissions in the year 2010 will amount 83.2 percent of the 1990 level.
- In case of unfavorable combination of all the parameters (GDP growth rate – 7.1 percent, CO_2 emissions in the year 2002 – growth by 10 percent, elasticity – 0.5) which is highly unlikely, then in that case CO_2 emissions in the year 2010 will amount 94.3 percent of the 1990 level.

Thus, under no scenario of economic development GHG emissions will exceed the Kyoto budget level. All previous forecasts confirm this fact if we calibrate them according to real GDP growth rates.

Figure 3.1 presents dynamics of CO_2 emissions in case of different scenarios of GDP growth and sensitivity to benchmark parameters.

Figure 3.1

Dynamics of CO_2 emissions in percentage to the 1990 level depending on different scenarios of GDP growth and analysis of sensitivity of the benchmark parameters



Moreover, even in case of the most unrealistic scenario Russia not only undoubtedly fulfils the Kyoto obligations but it will have a sizable quota surplus.

FORECAST ON THE BASIS OF THE IET DATA

Recent GDP growth, which is observed in Russia, is a specific phenomenon that is called "recovery growth". Such fact economic growth cannot last indefinitely and sooner or later will come to an end. IET forecast (http://www.iet.ru/trend/11-03/11-03r.htm) takes into account the feature of the recovery growth. Four different scenarios are examined. The most important factors are dynamics on oil prices and successfulness of the market oriented reforms.

Table 3.6

Scenarios of a medium-term economic growth according to IET

	In case of reform	**Lack of reform**
Low oil prices ($/barrel18,5)	Scenario 1	Scenario 2
High oil prices ($/barrel 22,5 and more)	Scenario 3	Scenario 4

Source: IET materials.

Depending on what direction the events will be developing depends the future GDP dynamics.

Table 3.7

Scenarios of Russia's GDP dynamics

Growth rates (% a year)	2004	2005	2006	2007	2008	2009	2010
Real GDP							
Scenario 1	4.0%	3.0%	2.0%	1.5%	1.3%	1.2%	1.0%
Scenario 2	4.0%	3.0%	0.0%	0.0%	0.5%	1.0%	2.0%
Scenario 3	5.5%	5.0%	4.5%	4.0%	3.5%	3.0%	2.5%
Scenario 4	5.5%	5.5%	1.0%	2.0%	2.5%	3.0%	3.5%

Source: IET materials.

We mentioned above that elasticity coefficient depends on the GDP growth rates. On the assumption of that we recalculated elasticity coefficient as it is presented in *Table 3.8* for the fourth scenario which was taken by us as the basis.

Table 3.8

Dynamics of CO_2 emissions according to fourth scenario

	2003	2004	2005	2006	2007	2008	2009	2010
GDP growth	7.0	5.5	5.5	1.0	2.0	2.5	3.0	3.5
Elasticity	0.4	0.5	0.5	0.9	0.8	0.8	0.7	0.7
CO_2 growth	2.8	2.9	2.9	0.9	1.7	2.0	2.2	2.5

Source: Authors calculations.

The last line in the *Table 3.8*. shows CO_2 emissions growth. Parting from these growth rates, it is easy to calculate that CO_2 emissions will grow by 20 percent during the period between 2003 and 2012. If at present these emissions constitute 69–72 percent of the 1990 emissions level and by the year 2010 they will constitute 83–86 percent of the 1990 emissions level. Thus, on the basis of this forecast one can conclude that Russia will preserve a considerable quota surplus. It should be noted, that while calculating elasticity (http://unfccc.int/resources/docs/natc/rusncr3.pdf., p. 85), we took into consideration only the factor, which slows down the GDP growth rates. That factor increases elasticity. We did not take into account a stimulating influence of growing prices of the energy resources, which reduces demand on the energy resources and consequently emissions coefficient per GDP unit.

3.4. Economic estimate of the quota

Coming into force of the Kyoto Protocol results in the price growth on the natural gas. In case of the European Union increase in the natural gas consumption signifies one of the main ways of implementation of its obligations on the Kyoto Protocol. Russia can gain on the natural gas price growth in the near future because the European Union even now started implementing its policy on limiting GHG emissions.

Table 3.9

Possibilities on fulfilling obligations and quotas balance (CO_2 mln t)

Countries	Need to reduce or buy quotas	Possibilities for fulfilling obligations					
		Purchase of quotas	Export of gas, electricity, etc.	Export of quotas from Russian and Ukraine	Export of quotas from Eastern Europe	Additional carbon effluents	Emissions reduction in the country
EU	2,000	100	1600	0	400		–100
Japan	930	300		300	0		330
Other countries of «Umbrella group»	1,000	300		300	0		350
Total	3,930	700	1,600	600	400		580

Source: Authors calculations.

Table 3.9 contains analysis of different variants regarding requirements fulfillment of the Kyoto Protocol on GHG emissions reduction of the Annex 1 (without USA). It is envisaged that the European Union will be limiting quotas import.

Export of Russian natural gas will help the EU to avoid CO_2 emissions resulting from the burning of coal and/or heating oil.[10] If Russia exports additionally 259 million cubic meters of natural gas per year during 2008–2012 period will constitute 1.6 billion tons of CO_2.

According to some modest estimates, the quota price on the European market will constitute by the beginning of the first period of fulfilling obligations (2008–2012) about 50 US dollars per ton of CO_2. The feature of the European quota

[10] For comparison: combustion of a ton of natural gas in oil equivalent results in emission of 2.3 tons of CO_2 and coal – 3.9 tons of CO_2 , i.e. the difference constitutes 1.6 tons of CO_2.

market consists in the fact that according to the EU idea entry to the market will be limited. That will allow the price to remain at a rather high level.

European policy regarding GHG emissions will influence the natural gas and electricity market. More advantageous fuel from the point of view of fulfilling obligations according to the Protocol is the natural gas. That is why the savings on quotas will be transferred on the natural gas price. Taking into account calorific capacities of fuels and CO_2 emissions coefficients obtained from their burning, such transfer of GHG quota price on to the natural gas price will constitute about 65 dollars per 1000 cubic meters of natural gas.

As for trade in quotas then in the short-term one must proceed from the fact that first of all transnational companies will be buyers on the quotas market. They will be looking for possibilities of not only buying but of developing traditional businesses in Russia. That is why for the near future the trade in quotas will be carried out on the project basis. For that it is expedient to create a mechanism of granting quotas to Russian enterprises for the implementation of specific projects on competitive basis. Such mechanism as though is similar to "partnership projects" according to the Article 6, in reality fundamentally differs in that instead of the base line a competitive granting of a certain part of quota is used. In that case the Russian government decides which quota and under which project to grant to an enterprise. In case of partnership projects determination of the base line is done off the government control. It is in the hands of the world bureaucracy and brings profit to international consulting firms.

Considerable demand on quotas and consequently considerable proceeds from the sale of quotas can be expected in mid-term and long-term perspective. That is why, in the near future Russia must control the volume of quotas launched on the external market. Moreover, it is necessary to agree with the Ukraine on the coordinated policy on the quotas market. Otherwise, the Ukraine can drop the prices not only on the quotas but on the gas as well, because the markets for quotas and the natural gas are interconnected: purchase of the natural gas can substitute the quota purchase due to lower amounts of weighted GHG emissions in the burning of natural gas in comparison with the burning of coal.

In the near future Russia can let enterprises and organizations entering the quotas market that have project on the reduction of GHG emissions. By distributing quotas on a competitive basis, Russia will control the overall quota volume intended for external market. Moreover, Russia will avoid using the channel of "joint project" linked with high transaction costs and interference into Russia's domestic affairs.

According to the Kyoto Protocol and the documents adopted by the Seventh conference of the parties, Russia with other countries is obligated to have a testable monitoring and accountability mechanism. Everything else remains its internal affair. Russia has the right to choose such internal mechanism designed to manage GHG emissions, which considers the most efficient.

The Protocol will create additional incentives for the forestry, improving forest exploitation, registration of forest resources, etc. By using, for example, above-mentioned 605,000,000 tones of CO_2 equivalent according to the Article 3.4, the Government can attract considerable funds for improving the management system of sustainable forest exploitation and land tenure. For example, part of this quota can be sold to Japan in exchange for creating in Russia a monitoring system in the forestry and agriculture, strengthening the system of state management.

Thanks the Article 3.3 there appear additional economic incentives for improving a natural reforestation as well as creation of the forest shelter belts and other measures linked with protection of forests and agricultural resources. Absorbed as a result of these measures, carbon will have a market price (to be more precise, corresponding emissions quotas). Proceeds can fund measures taken in the forestry and agriculture.

Forest resources, to be more precise, their ability to absorb carbonic acid, represent an important component in Russia's quota potential. This potential is not registered fully and bases of the Kyoto Protocol should be developed further in the next documents that regulate posterior budget periods. For example, Russia's limit according to the Article 3.4 can be considerable increased. However, such increase will make sense only in case Russia creates a system of full carbon registration in the framework of forestry and agriculture till the year 2012. Presently available limit volume according to the Article 3.4 is more than sufficiently enough to finance corresponding measures.

Section 4. Analysis and forecast of Russia's energy sector development

In contrast to the previous forecasts of GHG emissions done on the basis of macroeconomic forecasts "up bottom", this Section contains "bottom up" forecast done on the basis of the analysis of the energy sector based on documents adopted by the Russian government. These documents are the following:

- "Major directions for the socio-economic development of the Russian Federation for the long-term" (Program developed by the Ministry of economic development and trade and adopted by the Government of RF); http://www.economy.gov.ru/merit/76;
- "Main provisions of Russia's energy strategy for the period up to the year 2020 (developed by the Ministry of energy and adopted by the Government); http://www.mte.gov.ru/docs/32/103.html;
- "Federal targeted program 'Efficient economy' for the period 2002–2005 and till the year 2010" developed by the Ministry of energy and introduced in the list of Federal programs for the year 2002 (in particular, the Section "Ecological aspects of the energy efficient development of the fuel and energy complex including energy saving treatment of ash-and-slad waste of the thermoelectric power stations and reduction in the volumes of GHG emissions". http://www.mte.gov.ru/docs/23/658.html.

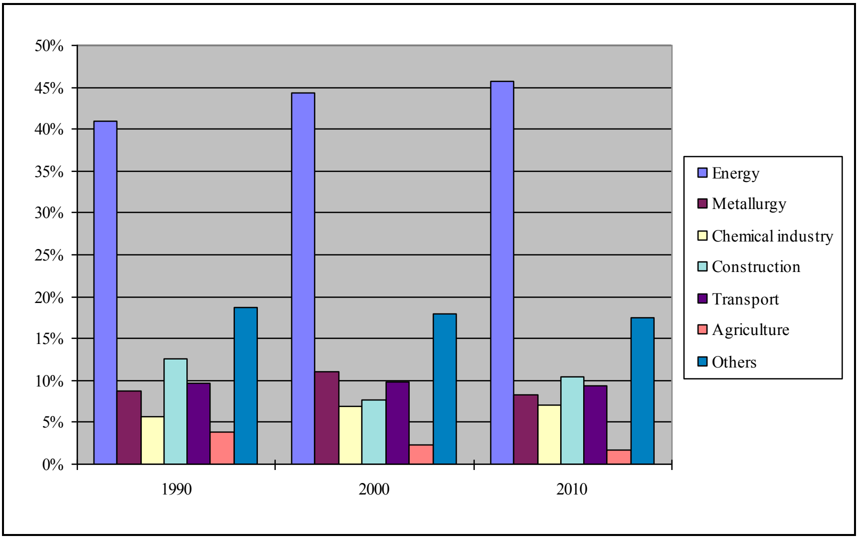
In addition to the official documents we used:

- Publications of the Bureau of Economic Analysis, in particular, "Russian strategy in reducing GHG emissions" drafted in the year 1998; (*Golub et al 1999*);
- Publications of the Center of nature management economics of the Higher School of Economics, developed in 1996–2001; (*Danilov-Danilian et al 2003*);
- Publications of the Institute of energy research of the Russian Academy of Sciences. In particular, paper "GHG emissions by Russia's energy complex for the period till 2010" developed in 2001 on the order of the Ministry for economic development and trade, Ministry of energy and RAO "UES of Russia". (Institute of the Energy Studies RAS, Moscow, 2001).

Forecast of the industrial structure of emissions for the year 2010 is represented in *Figure 4.1*. The biggest share in the overall CO_2 emissions produced by industrial sources will be of the energy sector – about 45 percent, metallurgy – 11 percent, transportation – 10 percent, production of construction materials and chemical industry – about 7 percent. The share of households in the overall CO_2 emissions will increase from 6 percent in 1990 up to 11 percent in 2010. This can be explained by reorientation of households to their own consumption of the energy resources because of worsening of problems linked with the energy and heat supply. This fact is confirmed by, for example, estimates of GHG emissions on the regional level. Inventory of emissions in the Novgorod region demonstrate that in the period 1990–1999 there was a considerable increase in the household consumption of coal, peat, firewood and other energy resources.

Figure 4.1

Forecast of industrial structure of CO_2 emissions in Russia (in % to the overall emissions)



Source: authors estimates.

Structure of the industrial production influences a little less than the volume and structure of GDP on the dynamics of GHG emissions. However, taking into account the fact that the share of the industrial production in Russian economy is sufficiently high and in the latest years took shape a sustainable growth in a number of industries, this factor is becoming more important from the point of view of dynamics of GHG emissions.

Energy prices

Prices of primary energy resources, electric energy and heat represent one of the factors directly influencing the volume of fuel consumption in the country and consequently GHG emissions. From the point of view of national GHG emissions domestic energy prices take special importance. Instability of domestic prices during last decade was highly considerable. Average energy price level increased in comparison with the 1990 level when a full scale state price subsidies remained by hundreds of percentage points. Change in domestic prices on energy resources is caused by several factors. Most important among them are:

- State of the world market of energy resources is subject to considerable instability. That was clearly demonstrated by a fifty percent reduction in oil prices (to a different degree on other types of fuel) down to 9–10 dollars per barrel in 1997–1998 and posterior increase up to the level of 36 dollars per barrel in 2000 and further by less drastic fluctuations. This fact although not always directly contributes to an increase in domestic energy prices in Russia. On the other hand world oil prices in contrast with GDP do not directly influence CO_2 emissions;
- Change in domestic energy prices is linked with further reform in the fuel and energy sector designed to liberalize the electric energy market and lifting of natural gas prices closer to the world ones.

However, according to some experts' opinion (*Gurvich et al. 1997*) price elasticity of energy demand in Russia is very low. For example, price growth on liquid types fuel during last years practically did not tell on its consumption volume. Reduction in the real price on electricity and gas resulted in the growth of their consumption (Main clauses of Russia's Energy Strategy till the year 2020 (Ministry of Energy of Russia, Moscow, 2001). This fact can be linked with the following factors:

- Existing energy use structure in Russia for the last years;
- Low real energy prices resulting from non-payments and lack of real levers to exert influence on defaulters;
- Relatively small changes in energy prices that are outside "threshold of sensitivity";
- Administrative measures directed to supply fuel to separate branches of economy and to the regions independently of the financial results derived from such supplies, etc.

As was demonstrated above, precisely the burning of fossil fuel represents the largest source of CO_2 emission. That is why, shifts in the energy demand resulting from the energy sources price change represents one of the major factors influencing the dynamics of CO_2 emissions.

Industrial modernization

Investments into new industrial technologies, modernization of industrial capital, managerial technologies (management), wide-scale simulation of innovations in the production and consumption sphere represent key factors that will determine the dynamics of GHG emissions in Russia in the coming decade. At present, the majority of industries, as before, widely use inefficient, according to current world standards, technologies that are more energy consuming and raw materials intensive. At the energy resources consumption level by the population the situation does not look better if worse that it was before the start of reforms in 1990s.

Unfortunately, despite separate positive examples, on the whole, the situation regarding introduction of the new technologies, capital renewals in Russian industry remains in rather worrisome state. Forecasted in the year 2003 technological crisis in the energy sector and many other branches of industry although seems rather overestimated demonstrates the fact that there are no radical changes in the sphere of technological innovations.

4.1. Parameters for the future development of the energy sector

Russia with its population reaching 2.8 percent of the world population and its territory that equals 12.8 percent of the surface of the Earth possesses between 12 and 13 percent of probable and about 12 percent of the prospected oil deposits, 42 percent of the resources and 34 percent of the natural gas deposits, about 20 percent of the prospected coal deposits and 32 percent of the brown coal deposits. Cumulative mining and extraction for the whole period of resources production amounts at present on oil 17 percent from the probable recoverable resources and on natural gas – 5 percent. Ensured extraction with prospected fuel deposits is estimated on oil and natural gas fro several decades and on coal – considerably more than that.

Lately up to 35 percent of the total amount of extracted energy resources in Russia is exported, including over 57 percent of oil together with oil products and 34 percent of the natural gas. Further development of the economy and the energy sector at the beginning will be realized in the conditions that are characterized by the limited financial possibilities by the need to use the available industrial, technological and personnel potential and as a result by the relatively low rates of restructuring and energy saving. Later on, as the financial potential increases resulting from the improvement of the general business cycle and the investment climate the rates of the positive structural and energy efficient tendencies will grow. That consequently will tell on the role of the fuel and energy complex and requirements made from the economy and society.

Volumes and structure of the per capita energy consumption

Energy strategy for Russia provides two possible scenarios of the socio-economic development of the country for the period till the year 2020. One scenario is favorable the other one is unfavorable. Starting with the year 1999 there is a revival of Russia's economy. GDP growth in the year 2000 amounted to 5 percent. According to the unfavorable scenario of economic development, personal household consumption reaches the 1990 level only by the year 2013. According to the favorable scenario of economic development it reaches the 1990 level by the year 2010. It is assumed that by the year 2002 personal household consumption grows twofold or in 2.8 times in comparison with the year 2000.

Russian Government envisages GDP growth by 29–30 percent by the year 2004 and by 80–90 percent by the year 2010 in comparison with the year 1999. In case of a slow economic development they forecast GDP growth by 12–13 percent by the year 2004 in comparison with the year 2000. That approximately corresponds to an unfavorable scenario of the Energy strategy.

At the same time, each time larger share of the household consumption will be directed at the satisfaction of new needs that are characteristic of the post-industrial society. This will result in the considerable change in the volume and structure of per capita energy use starting with the year 2010. In the unfavorable scenario per capita energy use will grow by the year 2020 by 25 percent in comparison with the year 2000. (up to 7.5–7.6 tons of equivalent fuel. In the favorable scenario this growth will be more intensive – in 1.4 times for the same period. In the year 2020 per capita consumption will constitute 8.3–8.4 tons of equivalent fuel per capita which is close to the 1990 level.

It is significant that per capita energy use ensuring foodstuffs will remain practically unchanged during the whole period. There will be higher growth energy use on transportation and housing especially in case of the favorable economic development.

Calculations of the energy use for the reviewed scenarios of economic development are done given different variants of energy saving plans. The unfavorable scenario of economic development correlates with moderate energy saving and the favorable one – with the intensive one. In case of the unfavorable scenario Russia's needs in the primary energy resources will be growing slowly – at the level of 12 percent by the year 2010 and by 18 percent by the year 2020. In the favorable scenario the energy saving will grow much more (correspondingly by 18 and 40 percent) and in the year 2020 it will reach the level of the year 1990.

Priority directions for the use of main energy resources

One can single out the following priority directions for the use of main energy resources:

- Natural gas – not for fuel purposes (production of fertilizers, raw material for chemistry, etc.), energy supply for the housing sector including heat and power plants, and as motor fuel for transport;
- Oil – meet requirements in motor fuels and raw materials for petrochemistry;
- Coal – for the electricity generation and production of coke and also as a fuel for households;
- Uranium – for electricity and heat production.

One of priority directions for natural gas and oil use during the period till 2010–2012 remains their export as the main source of currency earnings by the country. It is assumed that in case the share of recoverable fuel in probable resources amounts to about 25 percent then the resources of a certain type are well-developed and considerable increase in extraction is unlikely. In Russia oil production reaches this threshold. With respect to gas and coal these constraints are explained not by the deposits but by the cost of their development.

Forecast of gas production and consumption

It is well known that consumption of gas instead of coal and oil products sharply reduces GHG emissions. That is why the forecast of production and consumption of gas is analyzed in this paper in detail.

Main gas fields in Western Siberia that assure current production are greatly exhausted. For example, Medvezhye gas field is exhausted at 78 percent, Urengoy – 67 percent, Yamburg – 46 percent (figures for the end of 1990s). In the year 2000 gas fields that became operational in the period of falling production produced more than 85 percent of gas in Russia. Principal reserve fund of the prospected resources is situated in Western Siberia. There are unique in reserves gas fields on the Yamal peninsula, Zapolyarnoe gas field, less important gas-condensate fields in Nadym-Pur-Tazov region. Large gas fields are prospected on the continental shelf in Barents Sea, Sea of Okhotsk and Kara Sea. In Eastern Siberia and the Far East more than 2.7 trillion m3 of gas are prospected. However, only 7.4 percent of gas is produced there.

Undiscovered gas reserves that are situated on continental shelves in northern seas account for about 42.3 percent. Undiscovered land gas reserves that are situated in Eastern Siberia and the Far East account for about 43 percent, and the northern regions of Western Siberia account for 47 percent. In the European part of Russia principal additional gas deposits are forecasted in Caspian area. Natural gas there is characterized with high contents of hydrogen sulphide and carbon dioxide. In order to secure an extended reproduction of the sources of natural resources, it is necessary to develop prospecting work in promising hydrocarbon areas. It is required to do in order to prepare a reserve for deep exploration drilling. Perspective levels of gas production in Russia will be determined by the same factors that determine oil production. However, domestic gas prices will play an important role. Production levels of gas can amount in the year 2010 and in the year 2020 a volume of 655 and 700 billion cubic meters correspondingly.

In order to have secured natural resources base under the given gas extraction rates till the year 2020, it is necessary to secure increase in reserves of no less than 3.0 trillion m3 of the effective reserves for each five years (securing extraction cost of not more than 34–40 dollars per thousand cubic meters, and sale price including transportation costs not more than 70 dollars per thousand cubic meters). Nadym-Pur-Tazov region of Western Siberia will remain the main gas extraction region in the country for analyzed perspective. Although its share will come down by the year 2020 to about 64–50 percent against 87 percent at present.

Starting with the year 2006 it will be necessary to start developing gas fields in the Ob and Tazov bays, Shtokmanovskoe gas field and finally – gas fields in the Yamal peninsula. Advanced development of the Shtokmanovskoe field in comparison with the Yamal gas field is explained by the less volume of weighted costs by 1.5 times. Moreover, development of the Yamal gas field is held back due to the ecological problems.

Another large center of gas extraction will become Koviktin gas field situated in the Irkutsk oblast. The dynamics of gas extraction in East Siberia and in the Far East will be determined, to a considerable extent, by gas export to the countries of APR. In case of high demand on the Russian gas in the countries of APR, gas extraction from those areas can increase up to 50–55 bullion m^3. On the whole, gas extraction from present gas fields will amount by the year 2020 about 142 billion m^3. More than 76 percent of gas extraction should be developed from the new fields. A program designed to develop small and low output gas fields especially in economically developed European regions has a regional magnitude. Special attention should be paid to a complex development of natural gas resources of the Yamal-Nenets autonomous region – main gas extraction area in Russia.

Transit of natural gas from the territory of the Central Asia states (first of all, Turkmenistan) and natural gas imports for its consumption by the southern regions of Russia can have great importance.

Gasification of a number of Russian regions will continue including large industrial centers in the southern part of Western and Eastern Siberia, Far East, which is, first of all, explained by a need to solve ecological problems. Overall increase in distribution gas pipeline network will amount 75–80 thousand kilometers for five years including over 75 percent in the countryside. Polyethylene pipes will be used in the construction of pipelines, which will reduce costs and construction period, correspondingly, in 1.5–2 and 3 times. This will result in additional gasification of up to 10.5 million apartments, out of which 7.5 million in the countryside by the year 2021.

Liquefied gas will remain important in the structure of heat and water supply of the countryside and separate consumers. It is envisaged to increase liquefied gas consumption in 1.2–1.3 times.

Additional development of the Single system of gas supply and construction of gas transportation systems in Eastern Siberia and the Far East will be required for supplying gas to the consumers and securing its transit. During this period it will be required to replace 23 thousand kilometers of the pipeline, carry out modernization and replacement of gascompressor units of the total capacity 25 thousand Mwt and construct 22 thousand kilometers of new main gas pipelines.

The oil industry registers qualitative decline of resource base. Western Siberia and the Ural Volga region will remain the principal oil producing regions in the country although many large oil and gas fields are in the late stages of production with declining output. The share of hardly recoverable oil and gas deposits with low well production (less than 10 tons per day) amounts to 55–60 percent and continues growing. Potential oil and gas production from the "new" oil and gas fields located in the European part of Siberia, Eastern Siberia and the Far East is many times less than from the "old" ones and their development will be rather costly.

Calculations show that oil production in Russia will come to 335 million tons and 360 million tons in 2010 and 2020 correspondingly. Western Siberia will remain the principal oil-producing region in Russia for the whole period under analysis. At the same time, its share by the year 2020 will drop down to 58–55 percent compared with the current 68 percent. After the year 2010 a large-scale oil production will begin in Timan-Pechora region, on the Caspian continental shelf and northern seas, in Eastern Siberia and the Far East. Oil production in the East of Russia will constitute about 15–20 percent of the overall oil production by the year 2020. The task of increasing the oil recovery index remains urgent for the whole period under analysis.

In order to cover Russia's domestic demand in motor fuel, lubricants and other oil products as well as export of the oil products, the Energy Strategy envisages the growth in volumes of petroleum refining by the years 2015–2020 up to 220–225 million tons with simultaneous increase in the rate of the oil refining up to 70–80 percent in the year 2010 and up to 85 percent in the year 2020.

The coal-mining industry disposes of sufficient raw material base required to fully satisfy the needs of the Russian economy in coal. However, in the current economic conditions coal is considerably inferior to gas and oil fuels in the way of costs and ecological indices of its consumption by consumers and in reality closes fuel and energy balance. Increasing growth of production and economic capacities of the branch must ensure the risk reduction from a possible failure in gas production and atomic power stations construction. The branch must have indispensable reserves for increasing the coal production volumes up to 500 million tons per year by the year 2020.

According to the structure of fuel and energy balance adopted in Russia's Energy strategy demand for coal will amount 335 million tons in 2010 and 430 million tons in 2020. These volumes of coal production on the whole are supported with the prospected deposits, which excludes additional exploration work. It is very important that in contrast with the quickly growing prices on gas and oil coal prices during the period between 2001 and 2010 will be changing much slower. During the period from 2011 and 2020 due to a wide scale development of Kansko-Achinsk coalfields the coal price may even be reduced (by 10–15 percent to 2010 level). This goal can be achieved by developing the most efficient coal deposits, improving economic organization of the branch and, above all, scientific and technological progress in mining, treatment and transportation of coal.

Relative reduction of prices will remain in the next decade. This fact will serve as a good argument for increasing its role in the fuel and energy balance of the country. Satisfaction of demand on coal will be linked with the development of coal deposits in such federal regions as Kuznetsk and Kansko-Achinsk. Coal fields located in Eastern Siberia, Pechora, Donetsk and Sothern Yakutia will have regional importance.

Modernization of technological structure of coal production will consist in increasing the volume of coal digging. Its share will grow up to 80–85 percent by the year 2020. Large enterprises with the capacity of more than 500 thousand tons will account for about 80 percent of the overall coal production. The share of coal production of enterprises with small production capacity (less than 500 thousand tons) will increase form 4 percent in the year 2000 up to 15–20 percent in the year 2020. In the period 2001–2020 due to decreasing coal deposits and liquidation of loss-making enterprises (up to 60 million tons of production capacity), the need in construction of new capacities will amount to about 200 million tones, including 75 million tons in Kuznetsk coal-field, more than 70 million tons in Kansko-Achinsk coal-field, 20 million in the Far East coal-fields.

Improvement of the coal products quality is an important prerequisite for increasing coal competitiveness in the market of energy resources. A wide use of the most progressive methods of coal treatment is envisaged as well as transition to the international system of quality management (ISO 9000) at the coal mining enterprises.

Hydro resources of Russia by economically efficient potential are comparable with the current power output generated by all electric power stations of the country. However, their development (except small and micro hydroelectric power stations) requires very long periods and large investments. Taking this into account, possible power generation by hydroelectric power stations will constitute 170–177 billion kWh in 2010 and 190–200 billion kWh in 2020 on condition that electricity production costs (including the investment component) on the new hydroelectric power stations will not exceed 3.5–4 cents per kWh.

Hydroelectric engineering will be developing mainly in Siberia and the Far East ensuring basic regime of work for the thermoelectric power stations located in these regions. In the European regions construction of small size peak hydroelectric power stations will continue in Northern Caucasus. In particular, in the period till the year 2010 it is envisaged finishing the construction of Bureiskaya hydroelectric power station in the Far East, putting capacities into operation of hydroelectric power stations under construction, the largest of which is Boguchanskaya hydroelectric power station in Siberia, Ust-Srednekanskaya hydroelectric power station in the Far East, Irganaiskaya hydroelectric power station in Northern Caucasus. Beyond the year 2010 it is envisaged construction of economically justified hydroelectric power stations at the rate of 2–3.6 million kWh per five years. During the period from 2011 through 2020 there must be finished the construction of Boguchanskaya hydroelectric power station in Siberia, Nizhne-Bureiskaya and Vikuiskaya hydroelectric power stations in the Far East, and Zaramagskaya, Zelenchugskaya, Cherekskaya hydroelectric power stations in Northern Caucasus. Moreover, it is necessary to start constructing South-Yakutsk hydroelectric complex and cascade of hydroelectric power stations on the undercurrent of the Angara River with putting of the first units into operation before the year 2020. In order to ensure reliable performance of Unified Energy Systems of Russia the Energy Strategy envisages putting into operation of 2–3 nuclear power plants in the European part of Russia.

Thermoelectric power stations will remain the basis of Russia’s power industry for the whole period under analysis. Their role in the structure of the branch will constitute 68 percent by the year 2010 and 67–70 percent by the year 2020 (69 percent in the year 2000). They will produce 69 and 67–71 percent of all electric energy in the country correspondingly. Taking into consideration a complicated situation existing in the fuel extracting industries and expected high growth of electric energy generation by thermoelectric power stations (by about 40–80 percent by the year 2020), fuel supply of the thermoelectric power stations in the coming period will become one of major problems in the power industry.

Summed demand of Russia's thermoelectric power stations in the organic fuel will increase from 273 million tons of equivalent fuel in the year 2000 up to 310–350 million tones of equivalent fuel in the year 2020. Relatively small increase in fuel demand by the year 2020 in comparison with the electricity generation is linked with the complete replacement by that time of the existing uneconomical equipment with the new highly efficient one, which requires putting into operation maximum generation capacities. In the high version during the period between 2011 and 2015 it is envisaged to put into operation up to 15 million kw annually thus replacing the old equipment and ensuring consumption increase. In the period between 2016 and 2020 it is envisaged to put into operation up to 20 million kw annually. Any lag in putting new capacities into operation will result in a reduction in efficiency of the fuel consumption and correspondingly to the growth of its consumption by thermoelectric power stations in comparison with the levels fixed in the Strategy.

Development of power industry and heating systems

Under a favorable scenario reduction rates of GDP power intensity will correspond to the same indices in Japan posted in 1960–1995. Under a less favorable scenario it will correspond to the average indices of Western Europe posted during the same period. It is planned to reduce excessive consumption of natural gas domestically (first of all, by stabilizing its consumption by thermoelectric power stations) with replacement of gas by coal and partly by nuclear energy. However, it will nut result in large shifts in the structure of domestic consumption along types of fuel. During the period ahead electric power consumption will be growing in the most dynamic way. According to a less favorable scenario it will grow by 26 percent. According to a favorable scenario it will grow by 40 percent till the year 2010 and by 1.5 and 1.9 times by the year 2020 correspondingly in comparison with the 1995 level. GDP power intensity will be diminishing systematically after the year 2000.

Regional energy policy

The Energy Strategy envisages individual approach to the development of fuel bases and power supply to the main regions of the country. It is done on the basis of volume and structure of demand on the energy resources according to the forecasted dynamics of gross regional product volume.

In the future we expect contradictory tendencies regarding the location of power consumption across the territory of the country. Meeting the crisis and production revival in the European regions will more intensive than in the Eastern regions of the country due to the fact that manufacturing branches concentrated there (machine building and metal-working, light and food processing industries) will be increasing their production 3 to 3.5 times faster than fuel and energy complex and other basic branches of industry. In the Eastern regions of Russia production revival will be much slower due to domestic demand growth and export of natural resources. However, much smaller power intensity of the manufacturing industry in comparison with raw materials industries makes the tendency of the advanced growth of power consumption in the European regions of Russia not so obvious, especially in the coming decade.

In contrast with this, under a favorable scenario of socio economic development of Russia high rates of economic revival will be ensured by manufacturing (including science intensive) industry mainly located in the European regions of the country. It will result in the fact that their share in power consumption will start growing just after the year 2004 and by the year 2020 it will reach 53–55 percent of the overall volume of power consumption in the country.

4.2. Consolidated forecast of the power industry development

Table 3.11

Russia's power intensity in the primary energy

	1990	1995	1998	2000	2005	2010	2015	2020
Scenario 1	100	119	123	117	103	90	78	67
Scenario 2					98	77	64	54

Table 3.12

Summery forecast of energy saving

Year	Total, mln. Tones of fuel equivalent	Including power energy, billion kWh
2005	30–55	20–40
2010	105–140	60–130
2015	185–200	130–230
2020	300–420	190–300

Table 3.13

Summery forecast of Russia's power sector development

	2000	2005	2010	2015	2020
Production of primary energy resources – total – mln tones of fuel equivalent including:	1417	1430/1500	1455/1575	1500/1660	1525/1740
		308	305	305	305
Oil and condensate mln. T	323	327	335	345	360
Natural and associated gas, billion м^3	584	580/600	615/655	640/690	660/700
Coal, mln. T	258	270/300	290/335	320/370	340/430
Nuclear energy, billion kWh	131	155/175	190/205	210/260	235/340
Hydro energy, billion kWh	165	165/170	170/177	180/190	190/200
Non-traditional renewable energy resources, mln tons of fuel equivalent	1	3–4	5–7	8–12	12–20
Aggregate electric power generation billion kWh	876	970/1020	1055/1180	1135/1370	1240/1620
Volume of petroleum refining, mln T	174	175/185	185/200	190/220	200/225
Aggregate heat production mln Gcal	2060	2120/2185	2200/2315	2300/2470	2420/2650

**Note*: in numerator – for unfavorable scenario, in denominator – for a favorable scenario of economic development.

At present, evolution of the living standard and the mode of life of the population become the main factor determining the dynamics of domestic power consumption. The living standard growth will considerably change the volume and structure of per capita power consumption. Under the favorable conditions of economic development per capita energy consumption will be rather intensive. As a result, in the year 2020 it will constitute 8.3–8.4 tons of fuel equivalent. Under an unfavorable scenario the volume of per capita energy consumption will grow up to 7.6 tons of fuel equivalent by the year 2020.

Section 5. General conclusions and recommendations

Research findings demonstrate that the Russian quota for the period 2008–2012 is sufficient for stable economic performance. Its use increases competitiveness of Russian goods on the European market and, first of all, on the natural gas markets. Moreover, Russia preserves the quota surplus in the amount of 10–25 percent of emissions budget. This quota Russia can use in the quotas market or preserve it for the next period which emissions budget is not yet approved.

In order to secure the lowest possible emissions growth Russia should create incentives for the GHG emission reduction. This will also secure additional incentives to the introduction of new technologies and structural changes in the economy. Moreover, it will be possible to avoid negative influence of the environment and in the future to reduce this negative effect in the absolute terms.

In order to apply this potential it is necessary to apply a whole complex of measures:

- Restraint of the resource sector growth directed at the reduction of its share in GDP;
- Creation of a mechanism for environmental management directed at controlling emissions of four substances: small particles, SO_2, NOx, CO_2;
- Introduce general limits on emissions of these substances and provide enterprises with corresponding quotas permitting them to trade the rights on emissions including GHG emissions quotas in the world market;
- Apply methods for evaluating health risks for determining environmental priority measures.

It is necessary to start preparing for the negotiations for the next budget period (beyond the year 2012). First of all, a reliable emissions forecast should be prepared as well as a more precise evaluation of capability of the Russian ecosystems to absorb GHG emissions.

Russia can benefit from the Kyoto Protocol. In case of distancing from the Kyoto Protocol all possible benefits can be lost. Moreover, Russia will suffer losses due to political damage, negative reaction of potential investors, economic strengthening of competitors. At the same time, benefits expected from the realization of the Kyoto Protocol can be obtained in case of realization of a number of institutional measures. The following actions are required in order to obtain those benefits: development and realization of a special state policy and measures directed at the realization of the Protocol, optimal use of its mechanisms. An active position on the international arena is required together with no less active structural economic policy.

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Annex. Scientific basis of the Kyoto Protocol and the political context for its ratification by the Russian Federation[11]

Scientific justification of the measures dealing with the changes in the global climate

Research of the global climate changes has been already continuing over thirty years in many countries of the world including Russia. Using the findings of this research the Intergovernmental Panel on Climate Changes formed according to the decision of the UN General Assembly #43/53 of December 6, 1988, concluded that during the last one hundred and fifty years (starting with the industrial revolution) an unprecedented growth of GHG is taking place, especially, of CO_2. This results in changes in atmospheric circulation and global average annual temperature increases. Such fast rates of the climate changes were not observed al least during the last one hundred and fifty thousand years and possibly over one million years which is substantiated with numerous paleontological data.

Anthropogenic character of the climate changes does not cause doubts of the vast majority of the world scientific community. This conclusion was published in the First Assessment Report of the Intergovernmental Panel on Climate Changes (1989) and submitted in December 1990 to the session of UN General Assembly and to the Conference on environment and development that took place in Rio de Janeiro in 1992.

The Third Assessment Report of the Intergovernmental Panel on Climate Changes (2002) concluded that the current growth rates of GHG and the average global temperature considerably surpass even those pessimistic forecasts that were made in the previous Second Assessment Report of the Intergovernmental Panel on Climate Changes. With the help of mathematical models possible scenarios of climate changes for a long-term perspective were made. During the current century average temperature on Earth can increase by 6 C. This will lead to a imbalance in the global ecosystem, unforeseen local effects, large scale damage for the economy, social sphere and environment.

Consequences resulting from climate changes are assessed by the Intergovernmental Panel on Climate Changes as *catastrophic* practically for all regions of the world including Russia. Two ways of actions are analyzed for cushioning

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[11] Using the materials by Danilov-Danilian and Kuraeva.

these effects: first, adaptation to the climate changes and second, reduction of anthropogenic influence of the climate system (reduction of GHG emissions). Precisely these ways were approved by the international scientific community and were adopted in the main UN documents on the issue of climate changes.

International agreements on the global climate

United Nations General Assembly took a decision on the protection of the global climate in the interests of the present and future generation #46/169 of 19 December 1991. According to this decision the UN Framework Convention on Climate Change became effective in the year 1995. The Russian Federation in 1994 ratified it. In the preamble to the Kyoto Protocol, in particular, it is said that the World community adopts this agreement: "Concerned that human activities have been substantially increasing the atmospheric concentrations of greenhouse gases, that these increases enhance the natural greenhouse effect, and that this will result on average in an additional warming of the Earth's surface and atmosphere and may adversely affect natural ecosystems and humankind."

The ultimate objective of the FCCC is "to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

Measures defined by the FCCC envisage adopting of the main UN principle – the principle of general but differentiated responsibility taking into consideration the social and economic conditions of the countries. It is acknowledged that the industrially developed countries are carrying the main responsibility for the anthropogenic climate changes.

It s determined in the FCCC (art. 4 p. 2a) that the countries included in the Annex I of the FCCC (Including the Russian Federation) must adopt national policy to fight with climate changes and its negative consequences and to demonstrate leadership in the area for other countries.

In the elaboration of the FCCC economic mechanisms for the international cooperation designed to reduce GHG emissions and support of the measures directed at the adaptation to the climate changes were developed. They were included in the Kyoto Protocol to the FCCC adopted in December 1997 and ratified by 119 countries (by November 2003).

According to the Kyoto Protocol countries included in Annex B (including Russia) receive quota for GHG emission (list of gases and their sources of emission are represented in Annex I) for the period 2008–2012. For Russia the quota is set in the volume of 100 percent of the 1990 level of emissions. Negotiations regarding responsibilities of the countries for further periods where Russia is to negotiate its future quota should start not later than 2005.

In order to reduce costs incurred on the emissions reduction, the Protocol envisages mechanisms of "flexibility" that suggest funding of measures directed at reducing GHG emissions in those countries where it is most profitable with further transfer of reduced emission numbers to the investor countries. For example, reduction of CO_2 emissions in the energy sector and the housing sector of Russia according available data costs ten times less than in Japan in the EU countries.

Political aspects of ratification of the Kyoto Protocol

The Russian Federation consistently conducts a course directed at strengthening contractual relationship within the framework of the UN system. From this point of view ratification of the Kyoto Protocol being one of the mechanisms of the realization of the UN Framework Convention on Climate Change undoubtedly would represent an important step in the direction of supporting the UN activities in the sphere of fighting the climate change. On the contrary, refusal to ratify contributes to undermining of the current practice directed at adopting global measures and shifts activity in this sphere to one-sided uncoordinated types of activity.

Not later than the year 2005 (most likely in 2004) international negotiations will be started on issues of qualitative obligations of the Parties of the Kyoto Protocol for the period after the year 2012. In case when Russia does not ratify the Kyoto Protocol, these negotiations most likely will continue without Russia's participation. Political consequences of Russia's non-participation in these negotiations and its isolation on the international arena in this sphere will be great. They will be more detrimental in case the US returns under the "umbrella" of the Kyoto Protocol before the year 2005.